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Guide for the Development of Environmental Monitoring and Surveillance Programs for Dredging and Sediment Management Projects

Environment Canada and
Ministère du Développement durable, de l’Environnement et de la Lutte contre les changements climatiques du Québec

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Foreword

This guide is intended to assist dredging specialists in the design of environmental monitoring and surveillance programs (EMSPs) for dredging and sediment management projects, and to provide practical instructions for developing and implementing such programs. It is heavily based on the more detailed reference report of Michaud (2000). Managers and environmental assessment practitioners involved in dredging operations will find a wealth of information that we hope will facilitate their work.

The *Guide for the Development of Environmental Monitoring and Surveillance Programs for Dredging and Sediment Management Projects is the outcome of a commitment on the part of the Navigation Coordination Committee* (NCC) of the St. Lawrence Action Plan to implement a Sustainable Navigation Strategy that includes the integrated management of dredging and sediments. This integrated management approach is aimed at optimizing and standardizing the processes and tools necessary for the assessment, approval, performance, surveillance and monitoring of dredging and management of sediment dredged in the St. Lawrence. Following the efforts of the Working Group on the Integrated Management of Dredging and Sediments (WGIMDS), in the early 2000s, seventeen recommendations were drafted in the aim of developing a genuine integrated management approach for dredging in the St. Lawrence (WGIMDS, 2004). Since 2004, several multi-stakeholder working committees (federal departments and provincial ministries, industry, non-governmental environmental working groups) have collaborated to develop the different tools proposed under the WGIMDS recommendations, including the development of guidance on environmental monitoring and surveillance for dredging and sediment management projects.

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1. Introduction

This document is intended to guide dredging project managers and environmental assessment practitioners in the design and implementation of environmental monitoring and surveillance programs (EMSP) adapted to their dredging operations. In the context of the planning, approval and control of dredging projects, it provides a common approach for environmental monitoring and surveillance. This approach proposes a uniform process that seeks to obtain comparable data among the various projects, while ensuring that an EMSP conforms with the needs identified in the environmental assessment of a dredging project.

The distinction between surveillance and monitoring activities is sometimes ambiguous. With the objective of an integrated management of dredging operations in mind, this guide adopts the following definitions, inspired by a review of the different definitions found in the literature (MDDEP, 2005; Michaud, 2000; AQÉI, 1999; EC, 1998; USEPA, 1994; Fredette et al., 1990):

- **Environmental surveillance:** Means and mechanisms put in place in order to ensure, during the performance of authorized work, compliance with the environmental measures determined in advance, generally at the environmental study stage. A surveillance program includes mitigation or offsetting, as well as the conditions, commitments and requirements stipulated by government or ministerial authorizations and by the relevant legislation and regulations.
- **Environmental monitoring:** Scientific approach that allows temporal and spatial monitoring of the evolution of the components of the natural and human environments affected by the performance of the project. The goal of monitoring is to validate the accuracy of the assessment and forecast of the apprehended impacts; measure the effectiveness of mitigation measures for negative environmental impacts; and react in a timely manner to any failure of a mitigation or offsetting measure or to an unexpected environmental effect. Environmental monitoring also serves to build a knowledge base to improve future work planning.

1.1 Context of the EMSP in the Environmental Assessment Process

When dredging or sediment management work is undertaken, it is essential to ensure that the impacts on the different components of the natural and human environments are minimized and residual impacts offset. This is why environmental screening assessments are carried out. However, for all kinds of reasons, uncertainties may persist with regard to the prediction of the impacts and the effectiveness of the proposed mitigation measures. The objective of an EMSP is to circumscribe these uncertainties in the best way possible, given that they sometimes arouse concern on the part of the authorities and the public. If applicable, the EMSP will propose corrective actions to be applied when breaches, failures or adverse effects are observed during project monitoring and surveillance. Figure 1 illustrates the context of application of an EMSP.

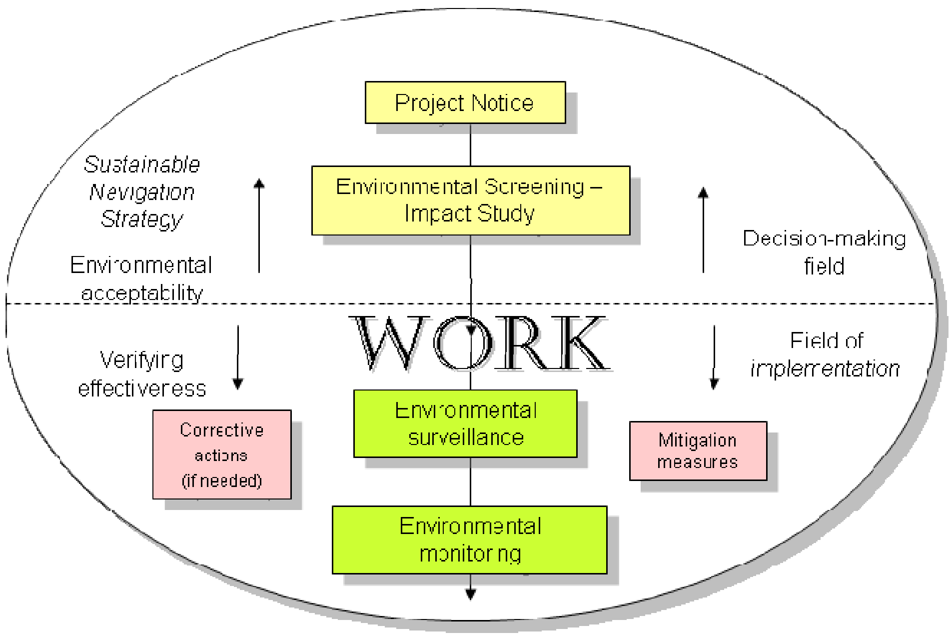

Figure 1 - Context of application of an EMSP (Modified from OFEFP and GREISOT, 1999)

Box A-1 of Appendix A gives an overview of the federal and provincial legal framework governing the environmental assessment process for dredging and sediment management projects. The EMSP is an integral part of this process. Guided by the environmental assessment, it is essentially designed to validate and direct the application of the decisions made within the context of the current assessment. It provides useful information to improve the environmental assessment of similar projects. This is why it is important to plan the monitoring and surveillance activities properly. Good planning facilitates the establishment of shared activities and makes it possible to take full advantage of their complementarity. Although monitoring and surveillance activities have distinct definitions, they are developed within the framework of a single planning process.

Environmental surveillance is a requirement arising from legal obligations, because its goal is to ensure that the work complies with the authorizations issued. It validates the representations made in the environmental assessment, which relate to the compliance of the activities, anticipated impacts and mitigation measures put in place. Although there is no doubt as to the relevance of environmental monitoring, there are no clearly defined criteria to determine its scope. However, an assessment of the following factors will help the project manager determine the scope of the projected follow-up program:

- <u>Novelty of a project:</u> if the technology has never been used or a project of this scope has never been undertaken, monitoring brings clarity to the real impacts of this type of project.
- <u>Environmental vulnerability:</u> if the project could threaten a particularly sensitive component of the environment, monitoring should be required (e.g., water withdrawal, wildlife habitat, species with designated status).
- <u>Hydrodynamic and hydrosedimentological conditions:</u> if the project is carried out in an area involving special conditions (e.g., tidal areas, sand bar, erosion).
- <u>Uncertainty of the analysis</u>: if the extent of the uncertainty of the impact analysis is substantial or if forecasting the impacts is complex.

- Scope of dredging operation: if the duration, volume and area of the dredging are substantial.
- Work schedule: if the impact assessment report was written a long time before the start of the project implementation phase, it is possible that certain environmental conditions have changed in unforeseen ways.

It is essential that an EMSP be drafted and implemented by competent and rigorous specialists. The resources allocated and the funds invested will allow for the collection of reliable data and information that is useful to all stakeholders.

Michaud (2000) established the guiding principles behind the drafting of an EMSP.

An EMSP must:

- be associated with objectives to determine the extent to which mitigation will protect important elements of the ecosystem and/or assess the accuracy of the forecasts and the impacts on these elements;
- be capable of gathering information on the important elements of the ecosystem at the proposed project location (ecosystem reference state);
- be designed in such a way that the outcomes can serve to detect the possible spatial and temporal variations in the effects on the study area;
- be centered on a series of indicators of the state of the environment that will reveal whether or not the project has significant effects on important elements of the ecosystem;
- be scientifically rigorous and based on verifiable impact hypotheses;
- include precise decision points and continue until the initial hypotheses of the project's effects have been confirmed or refuted;
- include several sampling campaigns covering a period compatible with the impact hypotheses or sufficient to allow examination of the effectiveness of mitigation;
- be based on a rigorous and predetermined statistical plan;
- include quality control and quality assurance mechanisms;
- be scalable and fairly flexible to allow insertion of new or improved monitoring techniques and to account for the outcomes of previous EMSPs;
- be manageable in terms of requirements and deadlines.

The federal and provincial legislation, regulations, guidelines and policies in force constitute the triggers of the environmental assessment process. This then leads to the carrying out of environmental studies, the scope of which is defined by the competent authorities. Following these studies, these authorities take a position on the project by issuing or not issuing authorizations. The EMSP activities are then initiated by characterization of the ecosystem reference state, i.e., its state before commencing the dredging and/or sediment management work. The monitoring and surveillance activities are performed during the work, with the monitoring activities also continuing after completion of the work. Figure 2 positions the monitoring and surveillance activities in the process of drafting a project and its environmental assessment. This figure also illustrates how the environmental monitoring and surveillance outcomes can improve the environmental performance of each phase of the project. This figure was adapted from the brief of the Comité sur le Suivi Environnemental of the Association Québécoise pour l'Évaluation des Impacts (AQÉI, 1999).

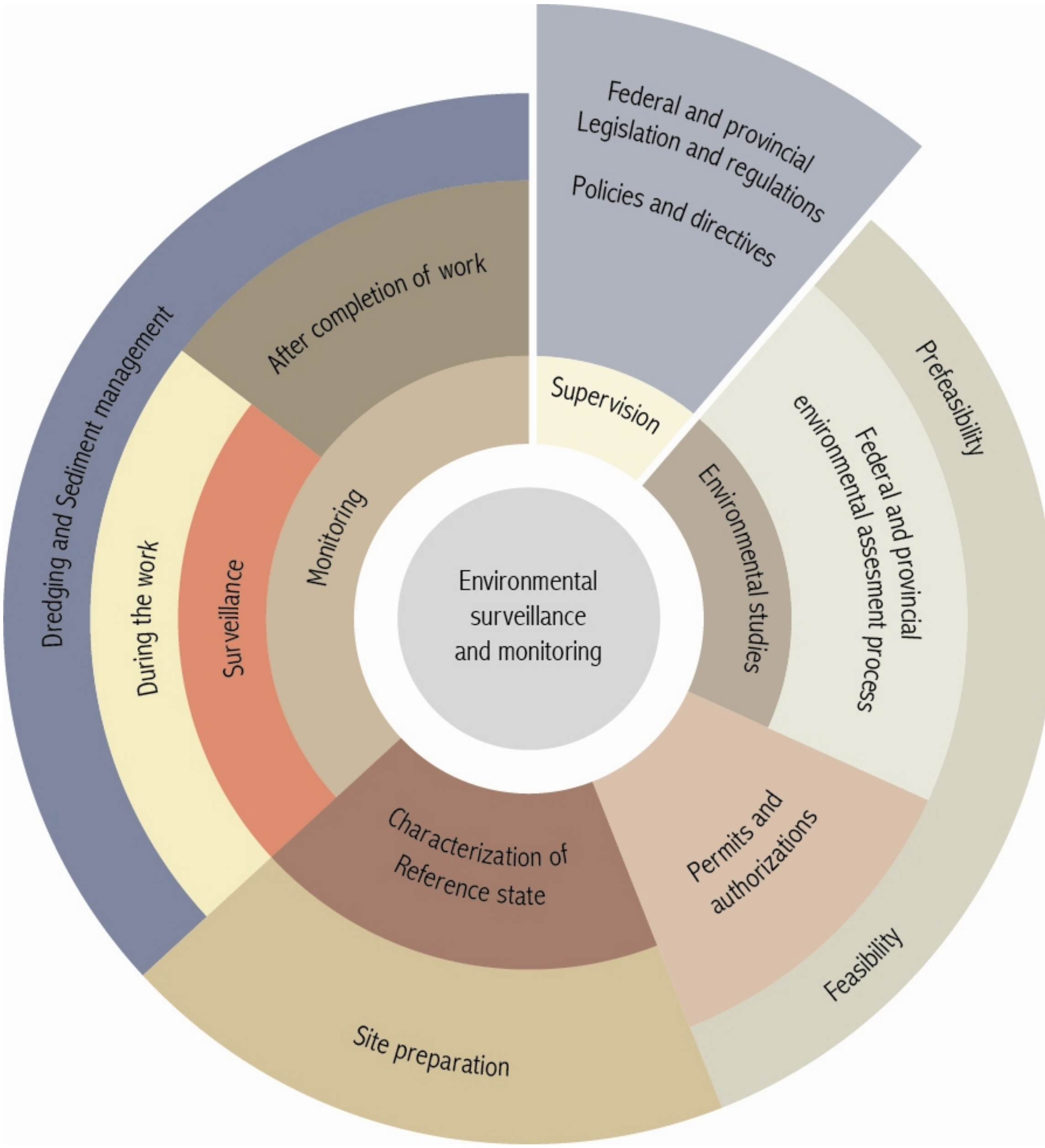

Figure 2 - Environmental monitoring and surveillance within a project (adapted from AQÉI, 1999)

1.2 Proposed Approach

The approach described in this guide is based on the work of Michaud (2000), which synthesizes a series of notions and information necessary for the drafting and implementation of an EMSP for dredging and sediment management work.

This approach proposes that an EMSP be carried out in twelve activities grouped into four distinct phases, as illustrated in Figure 3: the **drafting** phase (four activities); the **implementation** phase (six activities); the **communication** phase (one activity); and the **review** phase (one activity). The last phase allows an iteration of the process to review or update the stages of the previous phases, if necessary.

The next three sections of the document describe in detail the activities that constitute the four phases of an EMSP. Appendix B provides additional bibliographical references that are useful to the drafting of an EMSP for dredging and sediment management projects.

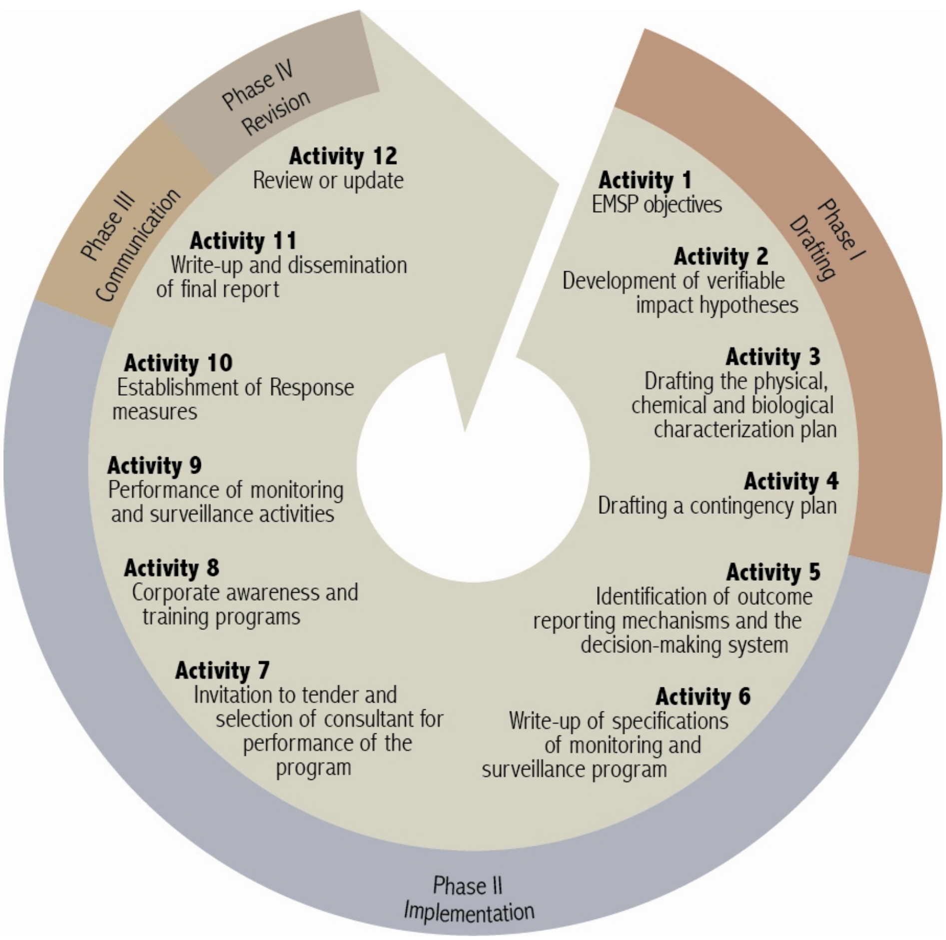

Figure 3 - Sequence of activities for the design and implementation of an EMSP

2. Drafting (PHASE I)

The following activities must be carried out for an EMSP (adapted from Michaud, 2000):

1. Formulation of the EMSP objectives.

2. Development of verifiable hypotheses of effects or impacts that will allow the EMSP to achieve its objectives.

3. Preparation of the physical, chemical and biological characterization plan:

   - determine and describe the assessment and measuring parameters that seek to confirm or reject the hypotheses;
   - determine the criteria these parameters must meet to be able to confirm the hypotheses (e.g., precision, accuracy, detection limits, reproducibility);
   - define the means used to guarantee the quality of the data;
   - define the data processing and interpretation criteria, both from the perspective of confirming hypotheses and achieving objectives;
   - determine the statistical methods used to process the data.

4. Drafting of the contingency plan.

   - in the event of confirming non-zero impact hypotheses, determine the responses that should be implemented to mitigate or eliminate these impacts;
   - identify the persons responsible for implementation of the responses.

As a general rule, the basic information (project activities and components of the environment) necessary to draft an EMSP can be found in the reports and records regarding the environmental assessment of the project concerned.

2.1 Objectives of the EMSP (Activity 1)

The first activity in drafting the EMSP involves describing the problem associated with the project under study (section 2.1.1) and formulating the objectives of the EMSP (section 2.1.2). Formulating the objectives of the EMSP makes it possible to identify the monitoring and surveillance needs. In general, the environmental assessment of the project provides the majority of the information needed to carry out this first activity as a whole.

2.1.1 Description of the Problem

The description of the problem seeks to identify the activities likely to result in impacts on any environmental components. Integrating the information gathered to describe the problem makes it possible to define the scope of the EMSP.

The description of the problem includes the context, identification of the available resources and drafting of the applicable timelines.

The following elements must be considered:

- the dredging and sediment management activities that must be covered by the EMSP: scope of the dredging project (duration, volume, technology used, etc.);
- the environmental components likely to be affected and identified in advance during the environmental assessment of the project (see Box A-2 of Appendix A);
- the applicable legislation and regulations, as well as the commitments made by the proponent and enshrined in the authorization records;
- the organizations, individuals and stakeholders interested in the problem;
- the timelines projected by the EMSP.

Most of the information required can be found in the project's environmental assessment reports. Moreover, examination of the previous studies involving the site concerned or pertaining to similar problems is useful to identify elements relevant to the description of the problem.

2.1.2 Formulating the Objectives of the EMSP

In general, an EMSP should have one or more of the following objectives:

For surveillance:

- ensure compliance with the legislation and regulations in force, and the conditions set out in the decrees, permits, certificates of authorization, specifications and dredging contracts;
- verify the validity and effectiveness of the measures taken to mitigate or offset the negative impacts anticipated during the performance of the work;
- verify the anticipated environmental effectiveness of the technologies and materials used;
- assist the proponent in quickly taking the appropriate measures to mitigate or offset the impacts (via the contingency plan), if a mitigation or offsetting measure proves to be ineffective during the performance of the work or in the event of impacts unforeseen or underestimated in the environmental assessment.

For monitoring:

- verify, over a specified period generally exceeding the period of performance of the work:
    1. the accuracy of the project's anticipated impacts on important elements of the ecosystem, particularly those that presented a high level of uncertainty;
    2. the validity and effectiveness of the measures to mitigate or offset the anticipated negative impacts;
- allow a rapid reaction if a mitigation or offsetting measure proves to be ineffective or in the event of unforeseen impacts after completion of the work;
- improve the forecasting capacity of the subsequent environmental assessments;
- observe the effects of implementation of new technologies;
- eliminate the measures that prove to be ineffective;

- contribute to improvement of the equipment, mitigation, protective measures and best practices in environmental management.

By keeping these elements in mind, the determination of the EMSP's project-specific objectives should derive directly from the objectives previously established during the environmental assessment of the project. The environmental assessments serve to identify the special concerns that must be taken into consideration at this stage. For example, these concerns may be associated with the presence of a specific type of contamination provoking major fears in the population, the presence of a special-status wildlife species or human health considerations. In this last case, a drinking water intake may be present near the site. Such elements are generally identified by the interested parties (e.g., federal departments and agencies, and provincial ministries, environmental groups, etc.) and the concerns they raise may be motivated by social, political or economic factors.

Box A-3 of Appendix A gives examples of formulating objectives.

2.2 Development of Verifiable Impact Hypotheses (Activity 2)

The second activity in drafting an EMSP consists of developing verifiable impact hypotheses. This activity begins with the analysis of the various components of the project, such as the impact sources, stressors, ecosystems, receptors and the apprehended responses (section 2.2.1). This analysis seeks to identify the impact mechanisms to be controlled and leads to the drafting of a conceptual model of the situation under study, by clearly establishing the cause-and-effect relationships (direct or indirect) (section 2.2.2). The development of a conceptual model makes it possible to better apprehend the problem by considering the level of uncertainty associated with the anticipated effects on the environment. This model results in verifiable impact hypotheses (section 2.2.3).

It is important to remember that the design of the sampling plans or programs of any EMSP must be based on hypotheses that anticipate the probable responses of environmental components to changes in the environment. The effort that must be devoted to this stage will depend on the comprehensiveness and the level of knowledge provided by the environmental assessment of the project.

2.2.1 Identification of the Components of the System under Study

The identification of the components of the system under study requires a precise knowledge of the activities of the dredging and/or sediment management project, and their interactions with all the environmental components. It is based on a compilation and analysis of the available information specific to the site or related to the problem under study:

- <u>preliminary analysis of information:</u> the analysis of the site-specific data is based on the site maps and plans, the characterization data, the impact matrix produced during the environmental assessment and any other relevant documents. The analysis of the information obtained from similar projects conducted previously can also prove very useful at this stage of drafting of the EMSP.
- <u>critical examination of the data gathered:</u> the critical examination of the data is intended to reveal possible deficiencies and biases in the available data in order to define the need for additional data and the means of obtaining it. This examination must be performed by taking

into account the impact sources, stressors, ecosystem components, receptors and the apprehended responses (see Box A-4 of Appendix A).

2.2.2 Drafting the Conceptual Model

A conceptual model is a tool for describing the links among the physical, chemical and biological variables of the ecosystems, the resources at risk and the expected changes attributable to a given project or to natural causes. As an outcome of the critical examination of the data carried out during the previous stage, the conceptual model is meant to be a schematization of the stressor migration mechanisms in the ecosystem after changes (expected) resulting from the implementation of the project. It must also specify the scientific limits surrounding the schematized mechanisms. The understanding that results from a well-developed conceptual model allows verifiable impact hypotheses to be formulated, which can subsequently be tested.

Based in particular on the impact matrix of the project's environmental assessment, the conceptual model is drafted by analyzing the sources of stress and the ecosystem elements. This analysis must be carried out according to a spatial and temporal framework that is consistent with the impacts to be verified. Box A-5 of Appendix A gives an example of an impact assessment matrix for dredging and sediment management projects. Box A-6 presents analytical elements for drafting the conceptual model.

The conceptual model describes how the stressors can affect the receptors. It can be simple and represented by a single schematic diagram. It can also be presented in the form of an impact matrix, a diagram or a summary table. For dredging activities, the conceptual model can be drafted in two parts. The first part presents the situation during the dredging activity and the second presents the situation after the dredging activity. Figure 4 shows an example of a simple conceptual model presented in the form of a schematic diagram.

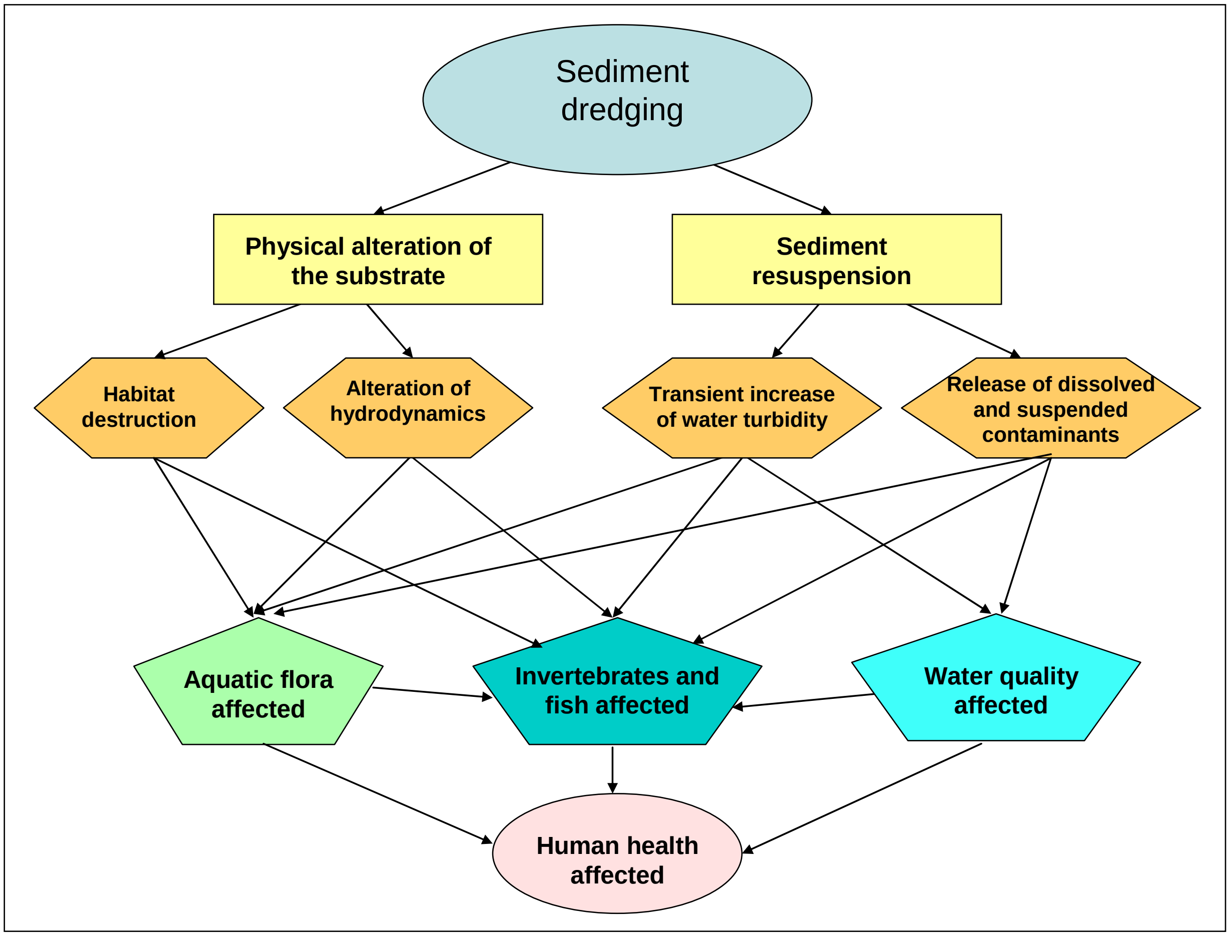

Figure 4 - Example of a conceptual model showing the links between stressors and biological receptors

Appendix C presents examples of conceptual models presented in tabular form. Table C-1 is an example of a conceptual model applicable to the dredging site during the work. In this example, the dredged sediments resuspended or lost during dredging cause a physical disruption of the environment and are one of the stressors related to the dredging activity representing the source. These suspended sediments are transported by different mechanisms to one of more of abiotic ecosystem components affected by the disruption. In a dredging context, the resuspended sediments are mainly directed to the water column; the hydrodynamic conditions determine their dispersion in the environment. The receptors exposed to the stressor through the targeted abiotic component must be enumerated. The apprehended responses must also be identified.

The distinction between the mechanisms governing the stressor (resuspension or loss in the bucket) and those governing the ecosystem (hydrodynamic conditions) make it possible to target the aspects inherent to the source and those inherent to the environment. This understanding is necessary for drafting the EMSP characterization plan (section 2.3).

Table C-2 presents an example of a conceptual model applicable to the dredging site after completion of the work. The sediments resuspended during dredging are therefore dispersed and deposited and the environment in which the sediments were dredged becomes a new environment. The environmental component mainly affected by the dispersed sediments remains the water column, but the ecosystem now being targeted is different because of this dispersion of suspended materials, which is dependent on hydrodynamic conditions. The receptors and targeted ecological entities therefore also change.

Tables C-3 and C-4 present examples of conceptual models for sediment disposal in open water, while tables C-5 and C-6 propose examples of conceptual models for capping contaminated sediments. Other examples, including for containment in a riparian or terrestrial environment, are also presented in Appendix C. These examples are not exhaustive and obviously do not apply to all dredging projects. However, the aspects covered in these examples are an adequate basis for drafting conceptual models dealing with similar activities.

2.2.3 Formulation of Verifiable Impact Hypotheses

The conceptual model must lead to the formulation of explicit hypotheses that will optimize the development of the characterization plans and, more specifically, the selection of the assessment parameters. These hypotheses must describe the potential impacts of the dredging and/or sediment management project. In general, the statement of the spatial and temporal limits, in the formulation of a verifiable impact hypothesis, allows these limits to be circumscribed in the surveillance program or in the follow-up program. Drafting conceptual models in terms of activity and time limit, both during and after the activity, makes it possible to target three types of verifiable impact hypotheses:

- those that exclusively require surveillance;
- those that exclusively require monitoring;
- those that require surveillance and monitoring.

Ideally, the formulation of a verifiable impact hypothesis should include the following six elements, based on the conceptual model:

- sources and/or stressors;
- the conversion or transportation mechanism;
- the spatial limits and the environmental (abiotic) components targeted;
- the temporal limits;
- the receptors;
- the apprehended negative responses.

The impact hypotheses may arise directly from specific concerns identified during the environmental assessment (or the assessment of the application for a permit or a certificate of authorization). However, depending on the project, the specificities of the site, the technology used and the progress of knowledge, several other impact hypotheses resulting from the drafted conceptual model can be added. Examples of verifiable impact hypotheses in relation to the conceptual models are presented in Appendix C.

2.3 Drafting the Physical, Chemical and Biological Characterization Plan (Activity 3)

This activity seeks to identify the descriptive tools required to verify the previously formulated hypotheses. It therefore specifies the technical and scientific means required to verify the hypotheses that will be the object of surveillance or monitoring. This stage must allow selection of the assessment parameters (section 2.3.1) and the related measuring parameters (section 2.3.2). It must also allow selection of the data analysis and interpretation modes and targeting of the action thresholds (section 2.3.3) based on the outcomes obtained. Table D-1 of Appendix D gives examples illustrating the different constituents of the characterization plan.

The drafting of the characterization plan must be based on a sufficient quantity of reliable data to be able to make the right decisions with an acceptable error rate (false positives and false negatives), while limiting the data acquisition effort to a minimal level (all the necessary data but only the necessary data). This process is summarized in the sections below and described in the following documents: USDE (1994), USACE (1994), USEPA (2006) and CEAEQ (1998).

2.3.1 Selection of the Assessment Parameters for Monitoring and Surveillance

The assessment parameters are a set of variables evaluated in order to test the verifiable impact hypotheses. These parameters must be clearly and precisely defined. It may be necessary to monitor several of them to validate a single hypothesis. One or more assessment parameters are selected by examining the set of receptors specified in the conceptual model and by answering the following questions:

- Is the assessment parameter significant in relation to the hypothesis to which it pertains?
- Is the assessment parameter appropriate to the phenomenon and the problem under study?
- Is the assessment parameter measurable or estimable?

Note that the spatial and temporal limits established in the conceptual model must also be taken into consideration.

Since several assessment parameters can be defined for the same verifiable impact hypothesis, it may be relevant to use assessment approaches that include a set of measurement parameters. In this first stage, these approaches, generally based on assessment of the weight of the evidence, must be considered in drafting the characterization plan in order to facilitate selection of the assessment parameters and the measurement parameters associated with them (see Menzie et al., 1996; CEAEQ, 1998). An example of the link between the verifiable impact hypothesis, an assessment parameter and a set of measurement parameters for a dredging project is provided in Table D-2 of Appendix D. This example posits the hypothesis that sediments will be resuspended in the water column during dredging operations, reach a spawning site located downstream from the work site and significantly affect this site’s potential. To verify this hypothesis, it is considered that the resuspended sediments will reach the spawning site located 5 km from the work site and that they will significantly affect yellow perch breeding (assessment parameter). To verify this assertion, suspended particulate matter (SPM) and turbidity (physical measurement parameters) will be measured at the work site and at the spawning site, where researchers will also verify clogging and the effect of SPM on fry survival (biological measurement parameter).

2.3.2 Selection of the Physical, Chemical and Biological Measurement Parameters

The measurement parameters are measurable descriptors associated with the assessment parameters and which allow verification of these parameters (see Table D-3 of Appendix D). Several measurement parameters are often required for a single assessment parameter. There are:

- **physical measurement parameters:** description of the physical properties of the stressor (solid, liquid, gaseous, particulate, size, surface type, etc.) and the ecosystem (hydrodynamic, temperature, etc.);
- **chemical measurement parameters:** description of the chemical properties of the stressor in terms of interaction and concentration in the environment;
- **toxicological measurement parameters:** description of the disruptions related to the toxicological response selected for the assessment parameter;
- **biological measurement parameters:** description of the characteristics of the receptor in terms of biological or ecological entities.

As a general rule, the measurement parameters are linked to relational tools that allow a connection to be made between the information generated by the measurement parameters and the assessment parameter to which they are associated. For example:

- **extrapolation between taxa:** toxicity data on a substitute species extrapolated to a species that is present in the target ecosystem;
- **extrapolation between responses:** acute toxicity data extrapolated to a chronic toxicity effect;
- **extrapolation from the laboratory to the targeted ecosystem:** effect on a species measured in the laboratory extrapolated to an effect in the target ecosystem for the same species;
- **extrapolation from an ecosystem to the target ecosystem:** data observed in related studies, extrapolated to the ecosystem under study;
- **estimation of indirect effects:** deductive methods, such as an event tree or a trophic network model;
- **estimation of the fate of the stressor in the target ecosystem:** dispersion estimation of the stressor in the environment;
- **estimation of concentrations in environmental compartments:** modeling of concentrations in aquatic organisms based on concentrations in the water.

The characteristics of the relational tool are determining factors in the selection of the associated measurement parameter. It is therefore appropriate to select the “measurement parameter/relational tool” combination as needed to verify the assessment parameters, that is:

- the level of effort to be provided based on the acceptable level of uncertainty/precision;
- the time required to obtain results;
- the sensitivity of the “measurement parameter/relational tool” combination.

The surveillance activity requirements may be different from those related to monitoring activities. Surveillance activities generally require obtaining results rapidly and a sensitivity of the “measurement parameter/relational tool” combination, in order to adequately prevent the environmental impacts by implementing the contingency plan in timely fashion (section 2.4). Monitoring activities, on the other hand, are generally more focused on the accuracy of the assessment.

2.3.3 Determination of the Action Thresholds

To respond effectively during monitoring and surveillance activities, action thresholds must be established in advance for each of the assessment parameters chosen. These thresholds are usually defined on the basis of standards, criteria and guidelines pertaining to environmental protection legislation and regulations. They can be defined on the basis of other issues identified during the environmental assessment or public consultations on the project. The assessors’ professional judgment also plays an important role. Table D-4 of Appendix D presents a summary of the main legal tools used in Quebec for dredging and sediment management projects. These tools may prove useful for establishing action thresholds.

In the absence of fixed standards or criteria for certain assessment parameters, the ecosystem reference state, assessed at the work sites, or the state assessed at regional reference stations, may be useful for establishing action thresholds.

In order to decide how to integrate the action thresholds associated with each of the assessment parameters used as management tools within the context of the EMSP, it is essential to have a clear understanding of the bases for their establishment. It is also important to establish, for each assessment parameter, a level of precision that will make it possible to judge whether or not the action threshold is exceeded. Additional information on this subject can be obtained in the following documents: USDE (1994), USACE (1994), USEPA (2006) and CEAEQ (1998).

2.3.4 Determination of the Quality Assurance and Quality Control Program

Quality assurance and quality control programs (QAQCP) consist of a set of internal and external practices of an administrative and technical nature; these are intended to ensure the quality of the data generated by the EMSP in terms of precision, accuracy, detection limit, reproducibility, etc. QAQCPs also make it possible to ensure that the data is used as intended (CEAEQ, 1998; Martel et al., 2002). The quality control process seeks to prove that the data gathering and analysis activities meet the predetermined quality objectives. The goal of quality assurance is to verify the effectiveness of the quality control program. Any environmental sampling and analysis program, particularly those geared to verification of a project’s impact assumptions, must include a QAQCP.

The quality objectives of the data must be established according to the following principles:

- produce good quality data by means of standardized and recognized sampling techniques;
- capture the natural spatial and temporal variability of the ecological indicators;
- be sensitive to sample contamination and the presence of extreme values due to the natural or special conditions of disruption sources;
- supply complete documentation and ensure reliability of all data.

In order for the data produced to be documented in a way that enables an unequivocal evaluation of the outcomes, each EMSP must define an analytical QAQCP that corresponds to its needs. Such a program must cover the following elements:

- quality assurance objectives (precision, accuracy, detection limit, data comparability, etc.);
- sampling and sample processing methods;
- custody, transport, conservation and storage of samples;
- calibration methods and calibration frequency;
- analytical protocols and experimental approaches;
- reference and quality control standards;
- reference documentation;
- data validation, verification and presentation;
- internal audits for quality control;
- preventive maintenance methods and schedule;
- specific methods to use for current assessment of data quality;
- corrective actions;
- quality assurance reports presented to management;
- references.

2.3.5 Selection of the Data Interpretation Methods

Generally, several measurement parameter/relational tool combinations are considered for a single assessment parameter. Selection of the data processing methods represents an important step for subsequent interpretation of the outcomes. This selection is largely modulated by each of the choices made during the previous steps of drafting the characterization plan.

When selecting the modes of interpretation of the outcomes, it is important to remember that the purpose of the analysis is to establish the extent to which the forecasts are accurate or confirmed by the data generated by the EMSP. For digital data, statistical data processing methods are generally used. Other data integration approaches are proposed in the literature. The selection of the data interpretation method must take account of the limits of each approach (Chapman, 1986; Menzie et al., 1996; USEPA, 1992a; 1992b).

2.3.6 Drafting the Characterization Plan

The outcome of all the actions performed to date in Phase I of the EMSP is the drafting of the characterization plan (sections 2.1 to 2.3). This plan specifically concerns the activities that must be performed to acquire the necessary data for the achievement of the EMSP's objectives. It must, at a minimum, include the following elements (described in more detail in Appendix E):

- selection of the sampling stations;
- determination of the number of samples;
- establishment of the sample collection frequency;
- selection of field and laboratory analysis methods;
- identification of the shipping procedures and sample conservation modes;
- selection of sampling equipment and procedures;
- establishment of the quality assurance and quality control program (QAQCP);
- establishment of the occupational health and safety program.

The scope of the characterization plan depends on the nature and volume of the sediments to be dredged or managed, the duration of the operations, the areas affected by them, the technologies selected for the performance of the work, the sensitivity of the receiving environment and the level of precision sought, depending on the EMSP's objectives. At this stage of the EMSP, it is necessary to establish the basis of comparison between the actual effects of the operations and the anticipated effects. For this purpose, data must be obtained that will allow the establishment of reference points attesting to the original site conditions prior to initiating the project; this will allow an adequate assessment of the future changes.

2.4 Drafting the Contingency Plan (Activity 4)

Every EMSP must have a contingency plan. The plan defines the management options by forecasting the actions to be taken based on the outcomes obtained during monitoring and surveillance. For example, if the outcomes show that the project produces effects beyond the predetermined action thresholds, it is important that the proponents/managers have a contingency plan that defines the conditions of response and the way to apply them rapidly. In addition, if the surveillance and monitoring performed according to the characterization plan make it impossible to verify whether or not the action thresholds are exceeded, an adjustment must be made.

The two triggering factors of the contingency plan are as follows:

- recognition that the action threshold is exceeded for an assessment parameter;
- the inability to affirm or invalidate, within the limits of the outcomes obtained and with an appropriate confidence level, that the action thresholds are exceeded.

The contingency plan must provide for the sequence of actions as soon as it is triggered. These actions must be arranged logically within a decision tree that specifies the persons responsible for each action and the decision-making process. The scope of the contingency plan must match the scope of the EMSP to which it is associated.

Two non-exclusive action categories can be set in motion when the contingency plan is triggered:

1. **Modification of the EMSP during performance:** Two cases can lead to the modification of the EMSP as initially drafted: the need to reduce the uncertainties due to an assessment or measurement parameter or the detection of unforeseen impacts. To better circumscribe the uncertainty regarding the assessment of the project's actual impacts, modification of the EMSP may consist of:

   - addition of assessment parameters;
   - addition or modification of measurement parameters;
   - addition or modification of sampling stations;
   - addition of samples;
   - modification of sampling methods;
   - modification of sample analysis methods.

2. **Establishment of new mitigation measures:** This action makes it possible to reduce the project's actual impacts when the predefined action thresholds are exceeded. The mitigation measures were defined during the environmental assessment stage of the project. However, in the event that certain mitigation measures established before or during the operations prove to be ineffective or that unforeseen impacts occur, it might be appropriate to apply additional mitigation measures. Appendix F presents examples of mitigation measures that apply to different sources that could have an impact on the water column or the terrestrial environment.

   When planning mitigation measures, it is important to ensure that they are technically, logistically and economically feasible and that they can be put in place quickly. Scenarios using alternative measures must also be anticipated to attenuate unforeseen situations. Mitigation can be effective on several levels:

   - **Source:** reduction of the scope (duration, volume, nature) of the activity.
   - **Stressor:** establishment of methods aimed at reducing the presence of the stressor or eliminating it, such as the use of a more effective technology.
   - **Ecosystem:** establishment of methods aimed at reducing the source when certain ecosystem-specific mechanisms risk dramatically increasing the stressor's effects, such as a reduction of dredging activities during adverse hydrodynamic conditions.
   - **Receptor:** establishment of systems allowing reduction or elimination of exposure of receptors to the stressor, especially for sensitive receptors.
   - **Apprehended response:** establishment of methods allowing elimination of the apprehended response of certain receptors to the stressor or establishment of compensatory measures, such as the enhancement of habitats to ensure that there will be no net habitat loss.

2.4.1 Emergency Preparedness Plan

An EMSP's contingency plan should include an emergency preparedness plan. It should be designed to identify the main actions to be taken in case of an incident or accident during the project and to specify the warning transmission mechanisms. The way the emergency preparedness plan is integrated with those of the municipalities concerned must also be specified. Box A-7 of Appendix A presents the elements of a typical emergency preparedness plan proposed by the Ministère du Développement durable, de l'Environnement et des Parcs du Québec (MDDEP, 2003a; 2003b; 2005; 2007). The instructions contained in the emergency preparedness plan must be an integral part of the awareness and training program for the employees who work on the different sites (see section 3.4).

3. Implementation (PHASE II)

It is possible to subdivide the implementation of an EMSP into six distinct activities:

- identifying the decision-making and outcome-reporting procedures;
- write-up of the EMSP specifications for submission to the authorities concerned;
- write-up of the request for proposals and selection of the consultants who will carry out the program;
- training the employees who will perform the work;
- performing the monitoring and surveillance activities;
- if applicable, triggering the contingency plan.

This implementation sequence obviously must be approved by the responsible authorities concerned.

3.1 Identification of Outcome Reporting Mechanisms and the Decision-making System (Activity 5)

During the implementation of the EMSP, the decision-making and outcome-reporting procedures must be clearly identified and it is important to do this before the work begins. If necessary, these procedures can be posted in the appropriate places. It is important to specify the importance of properly documenting the EMSP's activities and outcomes and maintaining documentation and logbooks for all the monitoring and surveillance activities. This documentation must be easily accessible and shared among the different stakeholders. Dissemination of the monitoring reports to the public is important and must be based on a multi-media communications plan (newspapers, Internet, workshop, conference, etc.).

The decision and communication chain must expressly include the following information:

- the name of the person responsible for communicating the outcomes;
- how the outcomes will be communicated;
- the names of the persons to whom the outcomes will be communicated;
- the time when these outcomes will be communicated;

- the name of the person responsible who can authorize implementation of the planned responses.

Since the responses can entail a modification of the work, temporary or even permanent shutdown, it is important that the chain of command be known in advance and approved by all stakeholders (proponents, contractors, consultants, government departments).

3.2 Writing the Specifications of the Monitoring and Surveillance Program (Activity 6)

Once all EMSP stages and components have been drafted and all the requirements of the sampling and analysis plan have been defined in detail, the EMSP specifications must be drafted. These specifications, which serve as the basis for the request for proposals, must at a minimum contain the description of the problem and the presentation of the objectives of the EMSP, the physical, chemical and biological characterization plan, the contingency plan and the decision-making and outcome-reporting procedures.

3.3 Invitations to Tender and Selection of the Consultant for Performance of the Program (Activity 7)

When a proponent wishes to delegate responsibility for the performance of the EMSP to a consultant or firm, an invitation to tender should be issued. Depending on the number of bids received, the proponent has the task of choosing the consultant or the firm that will best meet the needs set out in the specifications. This choice must be based, in particular, on the firm's expertise and experience, the expertise and experience of the personnel assigned to perform the work, the proposed methodology and the fees requested.

3.4 Employee Awareness and Training Programs (Activity 8)

Before commencing the dredging or sediment management work, the person responsible for performing the EMSP must inform the operators and other assigned workers about the required response measures for the protection of the environment. The responsibilities of each stakeholder must be specified to ensure quick and effective implementation of the contingency plan, if needed. The responsible person must inform employees about the project's potential repercussions and the importance of adopting environmental best practices during every phase of the work.

3.5 Performance of Monitoring and Surveillance Activities (Activity 9)

Once all the preceding stages are completed, the work and the monitoring and surveillance activities can begin. As soon as the outcomes of the analyses performed in situ or by the external laboratories are available, they must be compiled, interpreted and communicated to the stakeholders concerned in accordance with the mechanisms established in section 3.1. To facilitate interpretation of the outcomes by these stakeholders, graphic presentations are preferred. This allows for the quick detection of any possible overruns of the predefined action thresholds. It is important that the person responsible for the performance of the EMSP maintain, throughout the program, a data logbook describing the work accomplished, the weather conditions, any anomalies observed and the responses established.

3.6 Triggering the Contingency Plan (Activity 10)

The contingency plan can be activated based on the outcomes obtained during the monitoring and surveillance activities (section 3.5). This can lead to changes in certain aspects of the EMSP or the establishment of new impact mitigation measures (section 2.4).

4. Communication (PHASE III)

The production and dissemination of reports (Activity 11) is an important element of an EMSP. The frequency and number of reports that must be produced will be determined during the EMSP drafting phase. These reports should allow:

- the government departments to verify the effectiveness of the environmental assessment methods in place (the reports must be associated with recommendations for this purpose);
- the managers to integrate the outcomes into a database covering all EMSP outcomes in order to allow consultation of the database by specialists who will draft the future EMSP;
- decision-makers, the public and managers to access the information essential to allowing them to better protect the environment;
- the scientific community to increase and integrate knowledge in order to verify, validate and refine the verifiable impact hypotheses and the forecasting models.

The reports must describe the elements of the EMSP in detail, from its justification to the interpretation of the outcomes. They must clearly present the links that exist between the EMSP's objectives, the impact hypotheses resulting from the conceptual model and the outcomes obtained. The processes of drafting the verifiable impact hypotheses and the characterization plan must be explained, justified and documented. The reports must also explain the differences between the forecasted impacts and the observed impacts, if any, and describe the actions taken when the contingency plan is triggered.

5. Review (PHASE IV)

An EMSP (Activity 12) must be reviewed and updated in parallel with and in direct interaction with the program's other activities. At regular intervals, the outcomes of environmental monitoring and surveillance must be reviewed to determine whether it is appropriate to continue the program as is or to change certain elements: objectives, formulated impact hypotheses, characterization plan or contingency plan. The integration of new scientific knowledge or outcomes obtained from other EMSPs can also contribute to this review and updating process.

Only a periodic review of the EMSPs will make it possible to determine whether these programs completely fulfill their role. Through a periodic review of the EMSPs, it will also be possible to assess the state of our knowledge regarding the actual impacts of the projects and identify the research needs that will lead to the improvement of the assessment tools and the establishment of more effective mitigation measures.

6. Conclusion

This guide was designed to assist proponents and managers in the design and implementation of environmental monitoring and surveillance programs (EMSP) for dredging and sediment management activities. It proposes a rigorous approach, allowing scientific assessment of the scope of the dredging activities in order to establish the monitoring and surveillance activities that effectively meet prescribed environmental management and protection needs. The EMSPs drafted using the approach described in this guide should make it possible to circumscribe the uncertainties surrounding dredging and sediment management activities, verify the accuracy of the anticipated impacts and identify the appropriate actions to solve the problems identified.

Bibliography

AQÉI – Association Québécoise pour l'Évaluation d'Impacts. 1999. *Mémoire du comité sur le suivi environnemental*. Association québécoise pour l'évaluation d'impacts, Montreal. September 1999.

Canadian Environmental Assessment Act, 2012, S.C. 2012, c. 19, s. 52.

CEAEQ – Centre d'expertise en analyse environnementale du Québec. 1998. *Procédure d'évaluation du risque écotoxicologique pour la réhabilitation des terrains contaminés.* Centre d'expertise en analyse environnementale du Québec, Ministère de l'Environnement et de la Faune, Gouvernement du Québec. 139 pp.

Chapman, P.M. 1986. « Sediment quality criteria from the sediment quality triad: An example ». *Environ. Toxicol. Chem*. 5: 957-964.

Environment Canada. 1998. *Technical Guidance for Physical Monitoring at Ocean Disposal Sites*. Disposal at Sea Program. 55 pp.

Fisheries Act, R.S.C., 1985, c. F-14 (Current as of April 16, 2014).

Fisheries and Oceans Canada (2013). *Fisheries Protection Policy Statement*. October 2013, 23 pp.

Fredette, T.J., D.A. Nelson, J.E. Clausner, and F.J. Anders. 1990. *Guidelines for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites*. Technical Report D-90-12. U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS.

Loi sur la qualité de l'environnement (Chapter Q-2).

Martel, L., R. Chassé, A.M. Lafortune, and S. Bisson.2002. « Application Requirements for ERA of Contaminated Sites, » *in* Sunahara, G.I., A.Y. Renoux, C. Thellen, C.L. Gaudet and A. Pilon (eds.). *Environmental Analysis of Contaminated Sites*. Ecological & Environmental Toxicology Series. John Wiley & Sons, Ltd., pp. 257-280.

Menzie, C., M. Hope Henning, J. Cura, K. Finkelstein, J. Gentile, J. Maughan, D. Mitchell, S. Petron, B. Potocki, S. Svirsky, and P. Tyler.1996. « Special report of the Massachusetts Weight-of-evidence Workgroup: A weight-of-evidence approach for evaluating ecological risks ». *Human and Ecological Risk Assessment* 2(2): 277-304.

MDDEP (2007). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de dragage, de creusage ou de remblayage en milieu hydrique*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, July 1997, updated February 2007, 25 pp.

MDDEP (2005). *Le suivi environnemental - Guide à l'intention de l'initiateur de projet*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, July 2002, updated January 2005, 27 pp.

MDDEP (2003a). *Guide de réalisation d'une étude d'impact sur l'environnement*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, July 1997, updated fall 2003, 30 pp.

MDDEP (2003b). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de creusage ou de dragage d'entretien*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, April 2000, updated fall 2003, 20 pp.

Michaud, J.R. (2000). Environmental *Surveillance and Monitoring Program for Dredging and Sediment Management Projects. Design and Implementation Procedures*. Environment Canada, Environmental Protection Branch, Quebec Region, Innovation, Monitoring and Industrial sectors. Report 217 pp.

OFEFP et GREISOT – Office fédéral de l'environnement, des forêts et du paysage et Groupe EIE de Suisse occidentale et du Tessin (1999). *Surveillance et suivi environnemental des projets soumis à EIE en Suisse*. Aide à la définition et à l'application des mesures de protection de l'environnement, 96 pp.

USACE– United States Army Corps of Engineers. (1994). *Quality Assurance and Quality Control in Laboratory Bioassays of Dredged Material*. U.S. Army Corps of Engineers, Office, Chief of Engineers, Washington, DC.

USDE– United States Department of Energy. (1994). *Using the Data Quality Objectives Process in Risk Assessment*. Cercla Information Brief, Office of environmental Guidance, U.S. Department of Energy, EH-231-023/0794.

USEPA – United States Environmental Protection Agency. (2006). *Guidance on Systematic Planning Using the Data Quality Objective (DQO) Process*. EPA/240/B-06/001. Published by U.S. Environmental Protection Agency, Office of Environmental Information. Washington, DC.

USEPA (1994). *ARCS Assessment Guidance Document*. EPA905-B94-002, U.S. Environmental Protection Agency and Great Lakes National Program Office, Chicago, IL.

USEPA (1992a). *Sediment Classification Methods Compendium*. EPA-823-R006, U.S. Environmental Protection Agency, Office of Water, Washington DC.

USEPA (1992b). *Quality Assurance Management Plan for the Assessment and remediation of Contaminated Sediments (ARCS) Program*. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

WGIMDS – Working Group on Integrated Management of Dredging and Sediments.2004. *Orientation Document on Integrated Management of Dredging on the St. Lawrence River*. 21 pp.

APPENDIX A

Additional Elements

Box A-1 Environmental Assessment of Dredging and Sediment Management Projects

At the federal level, dredging projects are not "designated projects" under the *Canadian Environmental Assessment Act* (2012) [CEAA 2012], and therefore are not subject to an environmental assessment by the responsible authority (i.e., the Canadian Environmental Assessment Agency, the National Energy Board and the Canadian Nuclear Safety Commission). However, the Minister of the Environment may designate a project that is not on the list of *Regulations Designating Physical Activities*, such as a dredging project, if the project may cause significant adverse environmental effects or if there are public concerns about such effects. In addition, the CEAA 2012 (Sections 66 and 67) states that the federal government cannot carry out a project on federal lands, or exercise any power conferred on it under a federal law that could permit a project to be carried out in whole or in part on federal lands, unless the authority: a) determines that the carrying out of the project is not likely to cause significant adverse environmental effects; b) determines that the carrying out of the project is likely to cause significant adverse environmental effects and the Governor in Council decides that those effects are justified in the circumstances (under subsection 69(3)). In the event that dredging would be identified as a designated activity, project monitoring would be required under section 53 of the CEAA 2012.

At the provincial level, in southern Quebec, all dredging is subject to authorization under section 22 of the *Environmental Quality Act* (R.S.Q. c. Q-2). Large-scale dredging, over a distance longer than 300 metres or an area of 5,000 square metres or more, is also subject to government authorization under section 31.5, which is governed by the environmental impact assessment and review procedure defined in Division IV.1 of the *Environmental Quality Act*. This procedure is carried out in six phases, one of which allows public participation (directive, impact study, public participation, environmental analysis, recommendations and decision, supervision, control and monitoring). Most St. Lawrence River dredging projects are subject to this procedure. At the present time, a ministerial directive specific to the project is issued to the initiators of the project, specifying the basic elements that must be addressed in their environmental impact study. Drafting an EMSP is one of the requirements of the sectoral directives, particularly those concerning dredging work, drafted by the MDDEP (MDDEP, 2003[1]; 2007[2]). In fact, it is specified that the impact study must define the monitoring and supervision activities proposed for the entire study area and present the highlights of the programs to be established in the construction and operating phases of the project. The EMSP is implemented after authorization of the project.

The EMSP is generally drafted by the project proponent, accounting for the requirements of the government departments responsible for the authorizations and the requirements of any other interested party. Responsibility for implementing the environmental surveillance/supervision and monitoring activities also falls to the proponent. The proponent must inform the government authorities of the names of the persons or

[1] MDDEP (2003). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de creusage ou de dragage d'entretien*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, avril 2000, updated fall 2003, 20 pp.

[2] MDDEP (2007). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de dragage, de creusage ou de remblayage en milieu hydrique*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, juillet 1997, updated February 2007, 25 pp.

consultants designated to carry out the project. The proponent must also specify the form of the EMSP, the feasibility of timelines and the deadline for reporting the outcomes to the department concerned. At the federal level, in the case of a comprehensive study, the government department responsible for the environmental assessment must inform the public about the proposed EMSP and the outcomes obtained. It must also ensure that the EMSP is implemented and effective. At the provincial level, the MDDEP encourages the proponent to establish a disclosure strategy for the EMSP's outcomes, often through a Statement of Compliance Letter appended to the environmental study. The MDDEP ensures the implementation of the EMSP and enforces it.

Box A-2 List of Environmental Components for Surveillance in an EMSP for Dredging and Sediment Management Projects

Components	Dredging	Transport	Disposal / confinement			Pre-treatment	Treatment
			In open water	Littoral	Terrestrial		
Physical							
Bathymetry	x		x				
Hydrodynamic conditions			x	x			
Sediment grain-size distribution			x			x	
Turbidity	x	x	x	x	x		
Suspended solids	x		x	x	x		
Sediment regime	x		x				
Noise level	x	x		x	x	x	x
Sediment losses		x				x	
Drainage				x	x		
Quality of materials			x	x	x		
Chemical							
Ambient air quality	x*	x*		x*	x*	x	x
Sediment quality	x*		x			x	x
Soil quality				x	x	x	
Surface water quality	x		x	x	x		
Groundwater quality				x*	x*	x	
Vegetation quality	x						
Edible species quality			x*				

Components	Dredging	Transport	Disposal / confinement			Pre-treatment	Treatment
			In open water	Littoral	Terrestrial		
Wastewater quality					x	x	x
Air emissions quality					x	x	x
Quality of materials			x	x	x		
Quality of residues						x	x
Biological							
Benthic density / diversity			x				
Toxicity	x*		x*	x*			x
Bioaccumulation by organisms			x*		x*		
Bioaccumulation by plants				x*	x*		
Faunal and floral species			x	x	x		
Habitats			x	x	x		
* In the presence of contaminated sediments							

Adapted from Michaud (2000).

Box A-3 Examples of Formulation of Objectives

Confirmation of implementation and effectiveness of response measures

Objective: Determine whether the site can continue to receive dredged spoil without threatening the municipality’s water intake.

Environmental compliance

Objective: Determine whether the contaminant concentration in the sediments and the toxicity of the sediments comply with the quality criteria and the standards developed for the environment.

Accuracy of impact forecasts

Objective: Verify whether significant differences exist between the reference area and the different area studied before and after disposal of the dredged spoil.

Compliance of non-degradation of the environment

Objective: Verify whether the differences observed between the reference area and the different areas studied before and after disposal are indicators of the impacts on the population of a fish species of particular interest.

Box A-4 Description of the Aspects to be Documented for the Development of Impact Hypotheses

- **Source:** The different activities of a dredging project are a set of sources of environmental impacts (e.g., dredging, transportation, disposal, etc.). Each source must be described in terms of duration of the activity, sediment volume, technological novelty, etc. The project must therefore be compartmentalized into different “sources” with temporal scope.
- **Stressor:** Each source involves various stressors. The properties of the stressor causing modification of an environmental component with which it is in contact may be chemical, physical or biological. For example, for a stressor to be considered as such, its concentration in the environment must be higher than the natural level. This section provides information on the relative importance, background noise concentration, natural concentration, initial state, toxicity and persistence of the inventoried stressors, among other factors.
- **Ecosystem:** This section describes and sets the spatial limits of the ecosystem under study, including the elements designated by the interested parties (e.g., the municipality’s water intake or a specific habitat) and the specific elements present within defined spatial limits. This description involves the biotic and abiotic environmental components constituting the ecosystem under study.
- **Receptor:** Information concerning the biological or ecological entities observed or potentially present in the ecosystem (species, status) and the different groups (geographic, social, recreational, etc.) of citizens affected or potentially affected by the project.
- **Apprehended response:** Information on the apprehended negative responses linked to the stressor. The information concerning acute and chronic toxicity must be documented. The responses related to cumulative effects must also be specified here.

Box A-5 Example of an Impact Assessment Matrix for a Dredging and Sediment Management Project (adapted from Michaud, 2000[1])

	ENVIRONMENTAL COMPONENTS																						
	PHYSICAL					CHEMICAL					BIOLOGICAL				SOCIO-ECONOMIC								
	Bathymetry	Hydrodynamics	Sedimentology	Drainage	Erosion	Sediment quality	Air quality	Surface water quality	Soil quality	Groundwater quality	Aquatic fauna and habitat	Avian fauna and habitat	Terrestrial fauna and habitat	Riparian fauna and habitat	Recreational activities	Heritage and protected areas	Commercial fishing	Land use	Landscape aesthetics	Quality of life	Water intakes	Artesian wells	Human health
PROJECT COMPONENTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A. Sediment excavation	√	√	√			√	√	√			√	√			√	√	√		√	√	√		√
B. Dynamiting		√				√		√			√				√		√						√
C. Shipping					√	√	√					√		√	√		√		√	√			√
D. Overland transport							√	√	√				√	√	√			√	√	√			√
E. Open-water disposal	√	√	√			√		√			√				√		√	√			√		
F. Shoreline disposal	√	√	√	√	√	√		√	√	√	√	√		√	√	√	√	√	√	√	√		√
G. Upland disposal				√	√		√	√	√	√		√	√	√	√	√		√	√	√	√	√	√
H. Treatment area				√	√			√	√	√			√		√	√		√	√	√		√	√
I. Pretreatment							√		√	√			√	√	√			√	√	√			√
J. Sediment storage							√	√	√	√					√			√	√	√		√	√
K. Chemical storage							√	√	√	√					√			√	√	√		√	√
L. Treatment						√	√	√	√	√					√			√	√	√			√
M. Post-treatment						√	√	√	√	√					√			√	√	√			√
N. Residue storage				√	√		√	√	√	√					√			√	√	√		√	√
O. Residue disposal						√		√	√	√			√	√	√	√		√	√	√	√	√	√
P. Equipment traffic							√		√				√	√	√			√	√	√			√
Q. Demobilisation and decontamination							√	√	√	√			√	√	√				√	√		√	√

Note : the √ represent potential impacts

[1] Michaud, J.R. (2000). *Programme de surveillance et de suivi environnemental de projets de dragage et de gestion des sédiments. Démarche de conception et de mise en œuvre*. Environnement Canada, Direction de la protection de l'environnement, Région du Québec, Section Éco-innovation technologique. Rapport 217 pages.

Box A-6 Analytical Elements for Drafting a Conceptual Model

- **Analysis of the stressor:** The most accurate picture of the importance of the stressor's presence in relation to the environmental components of the ecosystem on the vertical (depth) and horizontal (breadth) planes. For example, contamination must be described in terms of type, scope and distribution.
- **Analysis of the environmental behaviour of the stressor:** Presentation of the transport and transformation mechanisms of the stressors. This analysis must be capable of targeting the stressor's temporal and spatial evolution and show the mechanisms acting in the short and long terms. In particular, it must account for the stressor's bioconcentration and bioaccumulation possibilities along the receptor chain. The elements of uncertainty in the analysis and the limitations of scientific knowledge must be stated and taken into account in the analysis. This analysis can allow rapid identification of the abiotic components and the receptors that will not be affected by the stressor during the carrying out of the project, and thus allow for their exclusion from the subsequent stages of the EMSP drafting process. Similarly, some abiotic components may have been targeted as a special concern during the drafting of the EMSP objectives and must be taken into consideration explicitly in subsequent stages.
- **Identification of the target receptors:** Inventory the biological or ecological entities, including the habitats and the sensitive areas (feeding, breeding, etc.) that can be presented within the spatial limits of the assessment. Determine those that are likely to be exposed directly, by contact with a stressor present in a given abiotic environmental component, or indirectly by the food chain. In a parallel process, this stage must also incorporate the special concerns advanced when drafting the objectives, including the aspects concerning human health, destruction of a habitat that may reduce the population of an important commercial species, or contamination of a harvested species.
- **Apprehended negative responses:** Determination of the type of response associated with exposure to the stressor. These responses, which can be manifested in the more or less long-term future, can be associated with direct or indirect exposure, or with more or less long-term effects.

Box A-7 Elements of a Typical Emergency Preparedness Plan

1. Description of the accident scenarios selected for planning: consequences, possibility or probability of occurrence, affected areas, etc.

2. Description of the various possible and probable situations for minor accident risks confined to the project location.

3. Relevant information in case of emergency: name, address and telephone number of responsible persons, list of equipment available, site plans, rendezvous points, list of safety equipment.

4. Emergency response structure and decision mechanisms within the organization.

5. Protective measures for the populations likely to be affected.

6. Notification and consultation procedures with the municipal and government agencies concerned.

7. Emergency preparedness update and reassessment program.

APPENDIX B

Documents That May be Useful in Drafting an EMSP for Dredging and Sediment Management Projects

Beak Consultants Limité (1996). *Guide technique pour la surveillance biologique dans le cadre de l'immersion en mer : Rapport révisé*. Prepared for Environment Canada, 166 pp.

CCME (1993). *Guidance Manual on Sampling, Analysis and Data Management for Contaminated Sites. Volume I: Main Report*. CCME Report EPC-NCS62E. December 1993.

CCME (1993). *Guidance Manual on Sampling, Analysis and Data Management for Contaminated Sites. Volume II: Analytical Method Summaries*. CCME Report EPC-NCS66E. December 1993.

Chevrier, A and P.A Topping (1998). *Lignes directrices nationales relatives à la surveillance des lieux utilisés pour l'immersion en mer de déblais de dragage et d'excavation*, Environment Canada, Marine Ecosystems Division, 29 pp.

Environment Canada and ministère du Développement durable, de l'Environnement et des Parcs (2007). *Criteria for Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation*. 41 pp.

Environment Canada (2002). *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River. Volume 1, Planning Guidelines*. Environmental Protection Branch, Environment Canada. 104 pp. (Volume - Navigation – Phase III).

Environment Canada (2002). *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River. Volume 2, Field Operations Manual*. Environmental Protection Branch, Environment Canada. 104 pp. (Volume - Navigation – Phase III).

Environment Canada (1998). *Technical Guidance for Physical Monitoring at Ocean Disposal Sites*. Disposal at Sea Program, 55 pp.

Environment Canada (1995). *The Inspector's Field Sampling Manual: A Sampling Manual and Reference Guide for Environment Canada Inspectors*. First edition. Enforcement Bureau, Environmental Protection Service, Environment Canada.

Environment Canada (1994). *Guidance Document on Collection and Preparation of Sediments for Physicochemical Characterization and Biological Testing*. Report EPS 1/RM/29.

Fredette, T.J., Nelson, D.A., Clausner, J.E., and Anders, F.J. (1990). *Guidelines for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites*. Technical Report D-90-12, U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS.

Fredette, T.J., Nelson, D.A., Miller-Way, J.A., Adair, J.A., Sotler J.A., Clausner, J.E., Hands, E.B. and Anders, F.J. (1990). *Selected Tools and Techniques for Physical and Biological Monitoring of Aquatic Dredged Material Disposal Sites*. Technical Report D-90-11, U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS.

Hodgins, D.O., and Harper, J.R. (1995). Technical Guidelines for Physical Monitoring At Ocean Disposal Sites. Contract report for Environment Canada. Quebec.

Kan, G. Dumouchel, F., Hennigar, P. and Quon, H. (1996). *Analytical Quality Assurance/Quality Control Guidelines for the National Ocean Dumping Program*. Preliminary report prepared by Environment Canada, Environmental Conservation Branch, Pacific & Yukon Region, Quebec Region and Atlantic Region.

Mann, G.S., McPherson, C.A., Sander, B.C. and Sloan, N.A. (1995). *Technical Guidance on Biological Monitoring for Ocean Disposal: Final Report*. Report prepared for Environment Canada, Hazardous Waste Management, Hull, Québec by EVS Environmental Consultants, North Vancouver, B.C.

MDDELCC – Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques du Québec et Environment Canada. In preparation. *Guide to* *physicochemical and toxicological characterization of sediments*. St. Lawrence Action Plan: Environment Canada, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec. Provisional title, in preparation.

MDDEP (2012). Sampling Guide for Environmental Analysis: Booklet 3 – Sampling Groundwater, Centre d'expertise en analyse environnementale du Québec, 54 pp., 1 appendix.*

MDDEP, 2010. *Guide d'échantillonnage à des fins d'analyses environnementales : Cahier 5 – Échantillonnage des sols, Québec*, Centre d'expertise en analyse environnementale du Québec.*

MDDEP (2009), *Guide d'échantillonnage à des fins d'analyses environnementales : Cahier 2 – Échantillonnage des rejets liquides, Québec*, Centre d'expertise en analyse environnementale du Québec.*

MDDEP (2008), *Guide d'échantillonnage à des fins d'analyses environnementales : Cahier 1 – Généralités*, Centre d'expertise en analyse environnementale du Québec, 58 pp., 3 appendices.*

MDDEP (2007). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de dragage, de creusage ou de remblayage en milieu hydrique*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, July 1997, updated February 2007, 25 pp.

MDDEP (2003). *Guide de réalisation d'une étude d'impact sur l'environnement*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, July 1997, updated fall 2003, 30 pp.[*]

MDDEP (2003). *Directive pour la réalisation d'une étude d'impact sur l'environnement d'un projet de creusage ou de dragage d'entretien*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction des évaluations environnementales, April 2000, updated fall 2003, 20 pp.[*]

Moore, D.W. (1994). *Quality Assurance and Quality Control in Laboratory Bioassays of dredged Material*. Proceedings of dredging '94, ASCE, Lake Buena Vista, FL., 728-736.

Pequegnat, W.E., Gallaway, B.J. and Wright, T.D. (1990). *Revised Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites*. US Army Corps of Engineers, Dredging Operations Technical Support Program, Technical Report D-90-8.

Thackson, E.L., and Palermo, M.R. (1988). *General Guidelines for Monitoring Effluent Quality from Confined Dredged Material Disposal Areas*. Environmental Effects of Dredging Technical Notes EEDP-04-9, U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS.

USEPA/USACE (1998). *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual*. EPA 823-B-98-004, February 1998.

USEPA/USACE (1998). *Great Lakes Dredged Material Testing and Evaluation Manual*. Final draft, September 30, 1998.

USEPA (1994). *ARCS Assessment Guidance Document*. EPA905-B94-002, U.S. Environmental Protection Agency and Great Lakes National Program Office, Chicago, IL.

[*] Ou version plus récente.

USEPA/USACE (1991). *Evaluation of Dredged Material Proposed for Ocean Disposal-Testing Manual*. EPA 503/8-91/001, February 1991.

USEPA/USACE (1995). *QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations - Chemical Evaluatio*ns. EPA 823-B-95-001.

USEPA (1992). *Quality Assurance Management Plan for the Assessment and remediation of Contaminated Sediments (ARCS) Program*. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA (1993). *Assessment and Remediation of Contaminated Sediments (ARCS) Program Pilot Scale Demonstration of Thermal Desorption for the Treatment of Buffalo River Sediments*. EPA905-R94-005, U.S. Environmental Protection Agency and Great Lakes National Program Office, Chicago, IL.

USEPA (1994). *Assessment and remediation of Contaminated Sediments (ARCS)-Program Pilot Scale Demonstration of Solvent Extraction for the Treatment of Grand Calumet River Sediment*. EPA905-R94-003, U.S. Environmental Protection Agency and Great lakes National Program Office, Chicago, IL.

USEPA (1994). *Assessment and Remediation of Contaminated Sediments (ARCS) Bench-Scale Evaluation of Soil Tech's Anaerobic Thermal Process Technology on Contaminated Sediments from the Buffalo and Great Calumet Rivers*. EPA905-R94-009, U.S. Environmental Protection Agency and Great Lakes National Program Office, Chicago, IL.

USEPA (1994). *Assessment and Remediation of Contaminated Sediments (ARCS) Program Pilot Scale Demonstration of Thermal Desorption for the Treatment of Ashtabula River Sediments*. EPA905-R94-021, U.S. Environmental Protection Agency and Great Lakes National Program Office, Chicago, IL.

USEPA (1991). *Test Methods for evaluating Solid Waste- Physical/Chemical Methods*. Revised Methods, Third Edition, U.S. Environmental Protection Agency, Washington, DC.

APPENDIX C

Examples of Conceptual Models

TablE C-1 Example of a Conceptual Model Applicable to the Dredging Site during the Work

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
	During the work		Mechanism	Abiotic component	Mechanism	Receptor		
Sediment dredging	Physical	Dredged sediments	Resuspension	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The sediments resuspended in the water column during dredging will reach the spawning sites of some fish species located downstream from the dredging site in sufficient quantity to significantly affect its potential.
		Noise	Diffusion	Ambient air		Fauna Human		The noise generated by dredging activities will affect the well-being of on-site workers and nearby residents.
	Chemical	Contaminants (adsorbés aux sédiments dragués)	Resuspension	Water column	Hydrodynamic and hydrosedimento-logical conditions	Human Fauna Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The contaminants resuspended in the water column during dredging (adsorbed to the particles or dissolved) will be adsorbed by the organisms in the environment in sufficient quantity to trigger acute effects.
		Contaminants (désorption du sédiment et diffusion)	Complexation Readsorption Release of potentially toxic natural substances	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Flora Human Particularity		The contaminants resuspended in the water column during dredging (adsorbed to the particles or dissolved) and absorbed by the organisms in the environment will be bioaccumulated by a harvested species (particularity) so as to render it unfit for human consumption.
			Volatilization	Ambient air	Dispersion	Fauna Flora Human Particularity		The contaminants associated with the dredged sediments will be volatilized in the ambient air in sufficient concentration to affect the health of on-site workers.

Table C-2 Example of a Conceptual Model Applicable to the Dredging Site after Completion of the Work

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
		After the work	Mechanism	Abiotic component	Mechanism	Receptor		
Dredging sediments	Physical	Suspended dredged sediments	Dispersion and sedimentation	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The sediments resuspended in the water column during dredging will reach the spawning sites of some fish species located downstream from the dredging site in sufficient quantity to affect its potential significantly.
	Physical	Undredged sediments	Sediment exposure	Sediments Interstitial water	Hydrosedimento-logical conditions	Fauna Flora Particularity		The grain-size distribution of the on-site sediments exposed after dredging precludes recolonization of the environment by a diversified benthic community.
	Chemical	Contaminants (adsorbed to the dredged sediments)	Dispersion and sedimentation	Water column	Transport by current	Human Fauna Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The contaminants resuspended in the water column during dredging (adsorbed to the particles or dissolved) will be absorbed by the organisms in the environment in sufficient quantity to trigger chronic effects.
	Chemical	Contaminants (desorption from the sediment and diffusion)	Complexation Readsorption Other	Water column	Hydrodynamic and hydrosedimento-logical conditions Environmental physicochemistry			
	Chemical		Volatilization	Ambient air	Dispersion			
	Chemical	Contaminants (undredged sediments)	Sediment exposure	Sediments Interstitial water	Hydrosedimento-logical conditions Environmental physicochemistry			The chemical nature of the sediments exposed after dredging will allow recolonization of the environment and result in harmful effects for the organisms that will return to it.

Table C-3 Example of a Conceptual Model Applicable to the Disposal Site during Disposal of Sediments in Open Water

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
		During the work	Mechanism	Abiotic component	Mechanism	Receptor		
Disposal or containment of contaminated sediments in open water	Physical	Sediment disposal at sea	Dispersion	Water column	Hydrodynamic conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The sediments resuspended in the water column during disposal will reach concentrations that can clog the gills of fish located downstream from the ocean disposal site, triggering their acute mortality.
			Sedimentation	Sediments receptors	Hydrosedimento-logical conditions	Fauna Human Flora Particularity		The sediments will be deposited in part on a spawning site, leading to significantly reduced productivity.
		Noise	Diffusion	Ambient air	Topography	Fauna Human		The noise generated by the disposal activities will affect the well-being of nearby residents.
	Chemical	Contaminants (adsorbed to the dredged sediments)	Dispersion	Water column	Hydrodynamic and hydrosedimento-logical conditions	Human Fauna Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The contaminants resuspended in the water column during disposal at sea (adsorbed to the particles or dissolved) will be absorbed by the organisms in the environment in sufficient quantity to trigger acute effects.
		Contaminants (desorption from the sediment and diffusion)	Complexation Readsorption Release of potentially toxic natural substances	Water column	Hydrodynamic and hydrosedimento-logical conditions Environmental physicochemistry	Fauna Flora Human Particularity		
			Volatilization	Ambient air	Dispersion	Fauna Flora Human Particularity		The contaminants associated with the dredged sediments will be volatilized in the ambient air in sufficient concentration to affect the health of on-site workers.

Table C-4 Example of a Conceptual Model Applicable to the Disposal Site after Sediment Disposal in Open Water

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
	After the work		Mechanism	Abiotic component	Mechanism	Receptor		
Disposal in open water	Physical	Deposited sediments	Transport	Water column	Hydrodynamic conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The grain-size distribution of the sediments at the disposal site precludes recolonization of the environment by a diversified benthic community.
	Physical and chemical	Deposited sediments	Sediment exposure	Sediments Interstitial water	Hydrosedimento-logical conditions	Fauna Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The chemical and physical nature of the dredged materials deposited will allow for the recolonization of the environment and have harmful effects on the returning organisms. The sediments transported downstream during ocean disposal will be deposited on a spawning ground, which will significantly reduce its productivity (clogging and toxicity for sensitive life stages). The sediments transported downstream during ocean disposal will be deposited on a nursery site of a valued (for whatever reason) fish species in sufficient quantity to chronically affect the population (reduced survival and breeding success).

Table C-5 Example of a Conceptual Model Applicable to On-site Sediment Capping Activities

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
	During the work		Mechanism	Abiotic component	Mechanism	Receptor		
Capping contaminated sediments in open water	Physical	Capped sediments	Resuspension and transport during placement of materials	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The sediments resuspended in the water column during disposal will reach concentrations that can clog the gills of fish located downstream from the ocean disposal site, triggering their acute mortality. The grain-size distribution of the sediments at the disposal site precludes recolonization of the environment by a diversified benthic community.
			Other mechanisms related to the technology used	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity		
	Chemical	Contaminants (adsorbed to the deposited sediments)	Resuspension and transport during placement of materials	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The contaminants resuspended in the water column during the work (adsorbed to the particles or dissolved) will be absorbed by the organisms in the environment in sufficient quantity to trigger acute effects.
		Contaminants (desorption from the sediment and diffusion)	Complexation Readsorption	Water column	Hydrodynamic and hydrosedimento-logical conditions Environmental physicochemistry	Fauna Human Flora Particularity		

Table C-6 Example of a Conceptual Model Applicable to the Site after Completion of Sediment Capping Work

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
	After the work		Mechanism	Abiotic component	Mechanism	Receptor		
Capping contaminated sediments in open water	Physical	Capped sediments	Bioturbation and erosion triggering failure of capping material and a leak	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The materials used to cap contaminated sediments do not provide protection against the hydrodynamic conditions of the watercourse, to the point of observing medium-term dispersion and downstream accumulation of contaminated sediments.
	Chemical	Contaminants (desorption from covered sediments)	Diffusion	Water column	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The contaminants dispersed downstream (adsorbed to the particles or dissolved) due to erosion of the capping site will be absorbed by the organisms in the environment in sufficient quantity to trigger acute effects.

Table C-7 Example of Additional Conceptual Models Proposed during On-shore Disposal or Containment

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
	During the work		Mechanism	Abiotic component	Mechanism	Receptor		
On-shore disposal or containment	Physical	Deposited sediments	Loss	Surface water	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The quantity of fine particles released into the watercourse by the outflow of the sediment settling tank, which serves as a containment enclosure for the contaminated sediments, exceeds the recommended level for protection of aquatic life.
	Chemical	Contaminants (adsorbed to the dredged sediments)	Loss	Surface water	Hydrodynamic and hydrosedimento-logical conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	Contaminants considered to be bioaccumulative and persistent percolate through the containment enclosure of the contaminated sediments, thus presenting an unacceptable risk for the aquatic environment.

Table C-8 Example of Additional Conceptual Models during Disposal in a Terrestrial Environment

Source	Stressor			Ecosystem			Apprehended response	Example of impact hypothesis
		During the work	Mechanism	Abiotic component	Mechanism	Receptor		
Terrestrial disposal and containment	Physical	Deposited sediments	Air transportation	Atmosphere	Weather conditions	Fauna Human Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The residential population near the work site is inconvenienced by the dust generated and transported into the air by the winds from the sediment dewatering site.
		Noise	Diffusion	Ambient air	Topography	Fauna Human		The machinery and vehicles used for dredging and transport of sediments generate noise that disrupts a tourist area during the high season.
	Chemical	Contaminants (adsorbed to the deposited sediments)	Air transportation	Ambient air	Weather conditions	Human Fauna Flora Particularity	Consideration of the apprehended responses determined in the literature for each of the target receptors	The quantity of contaminants (adsorbed to the dust) breathed by the population of the nearby residential area exceeds the level considered acceptable for human health.
		Contaminants	Desorption from the sediment and diffusion or percolation	Groundwater	Hydrodynamic and hydrosedimento-logical conditions Environmental physicochemistry	Human Fauna Flora Particularity		The quantity of contaminants found in the water of a sampling well installed nearby, after transport of contaminants in the soil, exceeds the acceptable criterion for human health.
				Runoff water (from the dike or spillway)	Weather conditions	Human Fauna Flora Particularity		
				Adjacent soil	Geochemical conditions	Human Fauna Flora Particularity		

APPENDIX D

Elements of the Characterization Plan

Table D-1 Examples of Interrelationships among the Assessment Parameter, the Relational Tool, the Measurement Parameters and the Action Thresholds

Verifiable impact hypothesis	Assessment parameter	Measurement parameter	Relational tool	Action threshold
The chemical and physical nature of the deposited dredged materials will allow recolonization of the environment and result in harmful effects for the returning organisms.	The chemical and physical nature of the deposited dredged materials creates harmful effects on organisms.	Cadmium concentration in the sediments	Methodology for derivation of criteria for the assessment of sediment quality in Quebec (in EC and MDDEP, 2007[1])	1.7 mg/kg
		BaP concentration in the sediments		0.15 mg/kg.
The contaminants resuspended in the water column during dredging (adsorbed to the sedimentary particles or dissolved) will be absorbed by the organisms in the environment in sufficient quantity to trigger potential chronic effects.	The contaminants resuspended in the water column will be present in sufficient concentrations to trigger acute effects on planktonic organisms.	Concentration of contaminants in the water column	Methodology for development of surface water quality criteria (in MDDEP, 2007[2])	Criteria for the protection of aquatic life (acute toxicity) for each contaminant.
		Elutriation test Acute toxicity tests on elutriate: *P. subcapitata* *D. magna* *B. calyciflorus*	Aucun	Response statistically higher than the detection limit for at least one toxicity test.

[1] Environnement Canada et ministère du Développement durable, de l'Environnement et des Parcs (2007). *Critères pour l'évaluation de la qualité des sédiments au Québec et cadres d'application : prévention, dragage et restauration*. 41 pages.

[2] MDDEP (2007). *Critères de qualité de l'eau de surface au Québec*. Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Direction du suivi de l'état de l'environnement (http://www.mddep.gouv.qc.ca/eau/criteres_eau/index.htm#juillet)

Table D-2 **Example of Interrelationship among a Verifiable Impact Hypothesis, an Assessment Parameter and Measurement Parameters for Monitoring and Surveillance Activities**

Verifiable impact hypothesis	Assessment parameter	Measurement parameter	
		Surveillance	Monitoring
Sediments resuspended in the water column during dredging work will reach a spawning site located downstream from the dredging site in sufficient quantity to significantly affect its potential use by some fish species.	The sediments resuspended in the water column during dredging work will reach the yellow perch spawning site located 5 km downstream from the dredging site in sufficient quantity to significantly affect the species' breeding success.	At the work site: Physical: SPM, turbidity, sediment regime	At the spawning site: Physical: SPM, turbidity, clogging of spawning site Biological: effects of SPM on fry survival

In this example, the assessment parameter represents an operational translation of the verifiable impact hypothesis by targeting a specific spawning site and a specific receptor. The measurement parameters for surveillance are identified at the dredging site and are essentially physical. A relational tool could be used to predict the environmental concentration at the spawning site based on the environmental concentration at the dredging site ("measurement parameter/relational tool" combination). For monitoring purposes, the measurement parameters are obtained at the spawning site and are physical and biological. These measurement parameters allow verification of modeling accuracy.

Tableau D-3 Exemples de paramètres de mesure physiques, chimiques, toxicologiques et biologiques

Category	Measurement parameter
Physical	• Bathymetry • Sediment grain-size distribution • Sonar imaging or any other means of verifying the predictions of the sediment-transport models
Chemical	• Qualitative chemical analyses (e.g., Odour, colour) and quantitative of the contaminants • Qualitative and quantitative chemical analyses of certain contaminants in environmental components (e.g., residual concentrations in tissues) • Analyses of the chemical forms or species present
Toxicological	• Toxicity of contaminants on the environmental components of the ecosystem assessed by means of laboratory toxicity assays
Biological	• Bioaccumulation in benthic organisms • In situ measurements of exoenzymatic activity of the bacterial community • Survey of the benthic communities • Integrative variables of the effects on the communities • Condition index of caged mussels

Table D-4 Criteria or Action Thresholds Linked to Environmental Components

Environmental component	Criteria/action threshold
Sediments	• Criteria for the Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation (EC and MDDEP , 2007[11]) • Marine sediment standards and quality criteria defined in *National Guidelines for Monitoring Dredged and Excavated Material at Ocean Disposal Sites* (Chevrier and Topping, 1998[12]) • Canadian Environmental Quality Guidelines (CCME, 2003[13]) • (http://st-ts.ccme.ca/?lang=en) • Grain-size distribution similar to reference stations
Surface water	• Quebec's surface water quality criteria (MDDEP; http://www.mddep.gouv.qc.ca/eau/criteres_eau/index.htm#juillet) • Canadian Environmental Quality Guidelines (CCME, 2003) • (http://st-ts.ccme.ca/?lang=en) • Percentage increase in relation to reference stations
Groundwater	• Criteria applicable to groundwater of the *Soil Protection and Contaminated Sites Rehabilitation Policy* (MENV, 1999[14]) (http://www.mddep.gouv.qc.ca/sol/terrains/politique/appendix_2_grille_eaux.htm) • Canadian Environmental Quality Guidelines (CCME, 2003) • (http://st-ts.ccme.ca/?lang=en)
Drinking water	• Drinking water/raw water standard (R.R.Q., 1981, c.Q-2, r.40[15]) • Technological constraints of the filtration station
Fauna/vegetation	• Diversity/abundance in relation to reference stations or initial state • Habitat function (breeding, feeding, etc.) • Toxicity in relation to reference stations • Bioaccumulation in relation to reference stations
Air	• Ambient Air Standards (R.R.Q., 1981, c.Q-2, r.38[16]) • Air Quality Criteria (MENV, 2002[17])

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[11] Environment Canada et ministère du Développement durable, de l'Environnement et des Parcs (2007). *Criteria for Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation*. 41 pp.

[12] Chevrier, A et P.A Topping (1998). Lignes directrices nationales relatives à la surveillance des lieux utilisés pour l'immersion en mer de déblais de dragage et d'excavation, Environnement Canada, Division du milieu marin, 29 pp.

[13] CCME – Canadian Council of Ministers of the Environment (2003). *Canadian Environmental Quality Guidelines.* 1,300 pp. (http://www.ccme.ca/assets/pdf/rev_rcqe_tableau_7.0_f.pdf)

[14] MENV (1999). Politique de protection des sols et de réhabilitation des terrains contaminés. Ministère de l'environnement du Québec, Service des lieux contaminés, Les Publications du Québec, 120 pp.

[15] *Règlement sur la qualité de l'eau potable.*

[16] *Règlement sur la qualité de l'atmosphère.*

[17] MENV – Ministère de l'Environnement du Québec (2002). Critères de qualité de l'air – Fiches synthèses. Ministère de l'Environnement du Québec, Direction du suivi de l'état de l'environnement, May 2002, 271 pp.

Soil	• Standards of the Land Protection and Rehabilitation Regulation (R.R.Q., 1981, c.Q-2, r.37[18]) • Canadian Environmental Quality Guidelines (CCME, 2003) • (http://st-ts.ccme.ca/?lang=en)
Work environment	• Standards/exposure doses (Regulation respecting the quality of the work environment, R.R.Q., c.S-2.1, r.11[19])
Noise environment	• Maximum noise levels depending on zoning
Aqueous releases	• Municipal standards for releases into storm, combined or domestic sewer systems
Solid releases	• Provincial legislation, regulations and directives on residual material management
Atmospheric releases	• Air emission standards (provincial and municipal legislation, regulations and by-laws)

[18] *Règlement sur la protection et la réhabilitation des terrains*.

[19] *Règlement sur la qualité du milieu de travail*.

APPENDIX E

Elements for Drafting the Characterization Plan

Selection of sampling stations

The reference stations must be selected so as to reveal any other source of potential disruption that could influence the characteristics of the variables measured at the surveillance or monitoring stations. Optimal study design also includes a temporal reference, i.e., data on the study site before the beginning of activities (reference state). Unfortunately, it is not always possible to generate this data before commencement of the dredging or sediment management activities.

It is generally easy to locate the reference stations for the components or the physical or chemical parameters. For example, to measure the changes in surface water or groundwater quality, one or two stations can be chosen upstream and downstream from the work area, in relation to the streamflow direction. To assess air quality, two to four stations can be chosen, located on the periphery outside the area of influence, if possible.

However, the selection of the reference stations for the biological components is more complex. Thus, to measure the impacts of the disposal of dredged materials on the biological communities, the reference stations must be chosen according the following factors (Germano et al., 1994):

- the reference stations must have the same biological community structure as the disposal site, as measured in the ecosystem reference state studies;
- the sediments must exhibit the same physicochemical characteristics as those of the disposal sites;
- the reference stations and the disposal site stations must be located at comparable depths and as close as possible to each other, while ensuring that the reference stations are located outside the area of influence. However, the reference stations must be set back from the movements of water masses at the disposal site.

The number of reference stations required is determined according to their representativeness and the scope of the sampling plan. In the case of disposal in open water, several reference sites may be necessary when the bathymetry and the geochemistry of the sediments at the disposal site proper as well as outside the disposal site are different.

For the surveillance of suspended particulate matter (SPM) at a dredging site, the water quality sampling stations should be located near sensitive areas and distributed among several sites in the SPM dispersion plume. At disposal sites in aquatic environments, water quality surveillance stations must be sampled before commencing the work to determine the natural variability of the parameters studied, particularly during meteorological and hydrodynamic conditions that significantly disrupt the environment. Periods of heavy ship traffic must also be considered as a disruptive factor. These aspects can also be verified for the reference areas.

However, the sampling plan remains scalable in the context of a follow-up program.

Determination of the number of samples

The number of samples to be collected at each station depends on the spatial and temporal heterogeneity of the variable being measured. A minimum number of samples must be established according to static parameters useful to the analysis. The process of defining data quality objectives is very useful for this determination.

Establishment of the sampling frequency

The sampling frequency depends on several factors, particularly the uncertainty regarding the technology used for dredging or sediment management or the stability of the disposal site.

Selection of the field and laboratory analytic methods

The purpose of this activity is to select the analytic method associated with the “measurement parameter/relational tool” combination previously selected. Due to the many factors to be considered in the selection of analyses and interpretation of raw data, it is difficult to establish a list of selection criteria in advance. Professional judgment therefore plays an important role in this choice. However, the selected criteria must at least allow establishment of the relevance of the data according to the measurement parameter sought and an assessment of the quality of the information according to the quality objectives defined in the quality assurance and quality control program.

The sampling planning process must include selection of the analytic methods (including determination of the detection thresholds), the sample volumes to be collected and the sample conservation methods. The *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River* (Environment Canada, 2002a; 2002b) and the *Guide de caractérisation physico-chimique et toxicologique des sédiments* (CEAEQ, in prep.) provide useful information relative to this activity.

Screening tools (analyses, tests, etc.) can also assist in the effective and economical acquisition of numerous data, either by quickly delimiting the problem area to be assessed (e.g., to determine the extent of contamination) or by assessing the effectiveness of remediation (e.g., to determine the sediment layer to be dredged). When the sector to be assessed has been delimited by means of screening tools, a sampling strategy can then confirm the screening results (CCME, 1993a; 1993b) and allow more precise characterization.

For definitive analyses (as opposed to screening analyses), the number of samples to be analyzed must be carefully determined based on the available budget and considering that the logistics of sample conservation, transportation and pretreatment require more handling and consequently are more costly.

Identification of shipping procedures and sample conservation modes

Depending on the different analyses that must be performed on the collected samples, it is important to select the appropriate sample conservation mode in order to preserve sample integrity. It is also important that the procedures for shipping samples to the different laboratories be adequate, which includes sample identification and packaging. It is therefore essential that there be good communication between the sampling teams and the laboratory teams, starting from the planning phase of the work. The *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River* (Environment Canada, 2002a; 2002b), the *Guide de caractérisation physico-chimique et toxicologique des sédiments* (CEAEQ, in prep.), and the documents of the Canadian Council of Ministers of the Environment (CCME, 1993a; 1993b) provide useful information relative to this activity.

Selection of sampling equipment and procedures

The sampling equipment and procedures must be selected taking account of the prevailing field conditions at the sampling stations as well as the sample characteristics and type, number and frequency, and analytic methods, etc. The *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River* (Environment Canada, 2002a; 2002b) and the *Guide d'analyse physico-chimique et toxicologique des sédiments* (CEAEQ, in prep.) provide useful information relative to this activity.

Establishment of the occupational health and safety program

The occupational health and safety programs must specify the personal protective equipment required (eyewear, boots, etc.) and the devices for surveillance of worker exposure to certain chemicals. The document entitled *The Inspector's Safety Guide: A Field Guide for Environment Canada Inspectors* (1996) presents good examples of safety measures for personnel responsible for collecting samples.

Bibliography

CCME (1993a). *Guidance Manual on Sampling, Analysis and Data Management for Contaminated Sites. Volume I: Main Report*. CCME Report EPC-NCS62E. December 1993.

CCME (1993b). *Guidance Manual on Sampling, Analysis and Data Management for Contaminated Sites. Volume II: Analytical Method Summaries*. CCME Report EPC-NCS66E. December 1993.

Environment Canada (2002a). *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River. Volume 1, Planning Guidelines*. Environmental Protection Branch, Environment Canada. 104 pp. (Volume - Navigation – Phase III).

Environment Canada (2002b). *Sediment Sampling Guide for Dredging and Marine Engineering Projects on the St. Lawrence River. Volume 2, Field Operations Manual*. Environmental Protection Branch, Environment Canada. 104 pp. (Volume - Navigation – Phase III).

Environment Canada (1996). *The Inspector's Safety Guide: A Field Guide for Environment Canada Inspectors*. Enforcement Bureau, Environmental Protection Service, Environment Canada.

Germano, J.D., Rhoads, D.C. and Lunz, J.D. (1994). An Integrated, Tiered Approach to Monitoring and Management of Dredged Material Disposal Sites in the New England Region. Rapport préparé par Science Applications International Corporation (SAIC) for U.S. Army Corps of Engineers, New England Division, Disposal Area Monitoring Systems (DAMOS) Contribution 87.

MDDELCC – Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec et Environment Canada. in preparation. *Guide to physicochemical and toxicological characterization of sediments*. St. Lawrence Action Plan: Environment Canada, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec. Provisional title, in preparation.

APPENDIX F

Examples of Mitigation Measures

Table F-1 Examples of Mitigation of Contaminant Migration Routes in the Water Column and in the Terrestrial Environment

<table>
<tr><th colspan="2">Water column</th></tr>
<tr><td>Reduction of the concentrations of resuspended and dissolved solids and contaminants and reduction of their current-driven transport by advection</td><td>Dredging/transport
1. Limiting the work to the suitable tidal or hydrological cycle
2. Reducing the dredging time and rate
3. Reducing the cutting depths
4. Optimizing the disaggregator speed with the power of the pump
5. Increasing the power of the suction pump
6. Installing a watertight hood near the disaggregator head
7. Improving the seals of the mechanical buckets, barges or backflow pipes and the buckets/railway cars or tankers used to transport dredged materials
8. Installing protective screens/curtains (impermeable membranes, sheet pile bulkheads, bubble curtains) at the job site or near sensitive areas
9. Prohibiting use of the overflow when filling barges/railway cars
Disposal/containment of materials in open water
1. Limiting the work to the suitable tidal or hydrological cycle
2. Reducing the volume of materials for each discharge
3. Installing submerged diffusers at the end of the pipes
4. Capping contaminated sediments with clean materials
5. Depositing sediments in geotextile bags on the barges
6. Considering the use of barges instead of backflow pipes
Upland disposal/containment
1. Reducing the hydraulic flows of the deposited materials
2. Adding flocculants or physical barriers to improve sedimentation
3. Verifying the operation or installation of a physicochemical effluent treatment system</td></tr>
</table>

Terrestrial environment	
Reduction of the concentrations of contaminants in gaseous, liquid and solid releases; reduction of the risks of migration of contaminants in the air, soil, groundwater and sewer networks, and reduction of the exposure routes of natural environments and humans	**Upland disposal/containment** 1. Maintaining sediments under water or keeping the surface layer wet throughout the containment day 2. Improving watertightness of dikes 3. Capping contaminated sediments with clean materials or installing impermeable membranes 4. Planting vegetation screens or erecting earthen berms surrounding the disposal site **Treatment of contaminated materials** 1. Reducing the treated flows 2. Verifying the capture of gaseous, liquid and solid releases and rerouting them to treatment facilities 3. Verifying the operation of the treatment equipment according to the manufacturer's specifications 4. Adding complementary treatment systems 5. Reexamining the choice of technological components of the entire treatment process

Source : tiré de Michaud, J.R. (2000). *Programme de surveillance et de suivi environnemental de projets de dragage et de gestion des sédiments. Démarche de conception et de mise en œuvre*. Environnement Canada, Direction de la protection de l'environnement, Région du Québec, Section Éco-innovation technologique. Rapport 217 pages.

APPENDIX G

Glossary

Adsorption: Quasi-reversible superficial fixing of liquid or gaseous substances (adsorbed substance) to the surface of a solid medium (adsorbent medium).

Advection: Transport of (thermal) energy or (chemical) material by physical displacement of a heat-conveying medium (air or water). Advection often is the dominant mechanism in relation to others such as diffusion (chemical) or radiation (thermal).

Aquatic containment: Submerged disposal site, not only covered but protected laterally because it is located in a depression at the bottom of or protected by submerged dikes, to avoid any dispersion of materials on the bottom.

Aquatic ecosystem: Aquatic unit, including wetlands (see definition), serving as a habitat for plant and animal communities and populations that influence each other.

Basic conditions: Conditions that exist before the performance of the project or that will serve as a reference point within the context of an environmental monitoring or surveillance program.

Benthos: All aquatic organisms living on or near sea, river or lake beds.

Bioaccumulation: Constantly increasing retention of a substance in the tissues of an organism throughout its existence (constantly increasing bioconcentration factor).

Bioconcentration: Retention of a substance in the tissues of an organism to the extent that the tissue content of this substance exceeds the content of this substance in the ambient environment, at a given time in this organism's life.

Biodegradable: A substance or a product likely to be decomposed completely by living organisms.

Biological process: Process whereby the life activities of bacteria and other microorganisms seeking food degrade complex organic compounds into more stable, simple substances.

Biological treatment: Treatment process that uses microorganisms to break down the toxic contaminants of waste into less toxic compounds.

Biotest: a) Technique of assessment of the biological effect of a substance contained in water by observation of the changes in a biological activity; b) Test during which a substance is put in contact with a given concentration with specified organisms in order to assess the substance's toxic effects on them. (Syn.: toxicity test, biological test).

Bioturbation: Transformation or degradation of sediments by the action of aquatic organisms moving or digging cavities within them.

Bucket: Equipment used to collect sediments. Generally consists of a pair of jaws that close on the sediments, or a clamshell that turns and bites into the sediments when it touches bottom.

Cancerogenic (or carcinogenic): Substances triggering the appearance of a cancer in a living organism.

Capitalization dredging: Dredging performed in ports and inland waterways with a view to expanding or deepening existing channels or basins, or creating new ones (initial dredging).

Characterization: Precise identification of the distinctive components of a substance, an environment or a process.

Chemical treatment: Treatment process that alters the chemical structure of the toxic contaminants of waste to reduce the toxicity, mobility or volume of waste.

Containment: Corrective actions that involve the construction of physical barriers to prevent the migration of contaminants from the matrices. In the case of contaminated sediments or dredged materials, their placement in a contained disposal site on land or located near the shore, where dikes or other similar structures isolate the materials from the neighbouring water, water bodies, surface water and groundwater during disposal.

Contaminant: Body contained in the water, the air or any other environment, which is not part of the normal composition of the environment and which gives it a harmful character. According to the Quebec *Environmental Quality Act* (EQA), the condition of the environment when a pollutant is present. According to the EQA, a solid, liquid or gaseous residue coming from industrial, commercial or agricultural activities, detritus, household garbage, used lubricant, demolition debris, pathological waste, animal cadaver, motor vehicle carcass, tires out of use, radioactive waste, empty container and scrap of any nature, excluding mine tailings. According to the EQA, a contaminant or a mixture of contaminants present in the environment in a concentration or quantity greater than the permissible level determined by regulation of the Government, or the presence of which in the environment is prohibited by regulation of the Government. According to the EQA, a solid, liquid or gaseous matter, a microorganism, a sound, a vibration, rays, heat, an odour, a radiation or a combination of any of them likely to alter the quality of the environment in any way.

Core drill: Device with which a sediment column (core sample) is collected, the analysis of which reveals the chronological or vertical distribution of the physical and chemical characteristics of the sediments.

Core sample: Sediment sample collected by a core drill.

Covering: Controlled and precise placement of contaminated dredged materials in an open-water disposal site followed by their covering with an insulating layer of clean materials.

Cumulative environmental effects: According to the Canadian Environmental Assessment Agency, changes suffered by the environment due to a project when the effects of this project are combined with those of other past, present and future human actions.

Data quality objectives (DQO): Predefined criteria applicable to the data used in a study or to the outcomes of this study, so as to ensure that the data is of acceptable quality to meet the program's needs.

Designated project: For the purposes of the CEAA, means one or more physical activities that (a) are carried out in Canada or on federal lands; (b) are designated by regulations made under paragraph 84(a) or designated in an order made by the Minister under subsection 14(2) of the Act; and (c) are linked to the same federal authority as specified in those regulations or that order. It includes any physical activity that is incidental to those physical activities.

Destruction (of fish habitat): The DFO Fisheries Protection Policy Statement (October 2013) defines destruction of fish habitat as follows: “an elimination of habitat of a spatial scale, duration, and intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.”

Dioxins: Group of about 75 chemicals of the chlorodibenzodioxin family, including 2,3,7,8-tetrachlorodibenzo-para-dioxin, generally considered the most toxic.

Dispersion: Spreading of a substance in a system (soil, water, air) by the action of a transport mechanism or other mechanism.

Disposal site: Zone in which disposal at sea of a substance or a waste is authorized, in accordance with the conditions of a valid disposal at sea permit.

Dissolved solids: Materials dissolved in natural water and wastewater.

Ecosystem: Ecological unit belonging to the biosphere, composed of living, animal and plant elements (biocenose) and inert elements (biotope). Ecosystems thus are the functional dynamic systems of the biosphere, within which living species are both producers and consumers within the food chains.

Ecotoxicity: Capacity of a substance to trigger toxic effects not only in living species but in their organizations, their relationships with inanimate matter, and their interrelationships (biological imbalances). The ecotoxicity of a substance is more specifically related to its long-term toxic effects.

Effluent: In the case of dredged materials, decantation water (return water) from a contained deposit under the effect of filling or disposal of dredged materials.

Environmental assessment: For the purposes of the CEAA (2012), assessment of the environmental effects of a designated project that is conducted in accordance with this Act. The environmental assessment of a designated project must take into account the following factors: (*a*) the environmental effects of the designated project, including the environmental effects of malfunctions or accidents that may occur in connection with the designated project and any cumulative environmental effects that are likely to result from the designated project in combination with other physical activities that have been or will be carried out; (*b*) the significance of the effects referred to in paragraph (*a*); (*c*) comments from the public — or, with respect to a designated project that requires that a certificate be issued in accordance with an order made under section 54 of the *National Energy Board Act*, any interested party — that are received in accordance with this Act; (*d*) mitigation measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the designated project; (*e*) the requirements of the follow-up program in respect of the designated project; (*f*) the purpose of the designated project; (*g*) alternative means of carrying out the designated project that are technically and economically feasible and the environmental effects of any such alternative means; (*h*) any change to the designated project that may be caused by the environment; (*i*) the results of any relevant study conducted by a committee established under sections 73 or 74; and (*j*) any other matter relevant to the environmental assessment that the responsible authority, or — if the environmental assessment is referred to a review panel — the Minister, requires to be taken into account.

Environmental components: Constituents of the natural environment. These are usually the following components: air, water, soil, terrain, vegetation, animals, fish and avifauna.

Environmental effects: For the purposes of the CEAA (2012), the environmental effects that are to be taken into account in relation to an act or thing, a physical activity, a designated project or a project are (*a*) a change that may be caused to the following components of the environment that are within the legislative authority of Parliament: (i) fish and their habitat, as defined in section 2 of the *Fisheries Act*; (ii) aquatic species as defined in subsection 2(1) of the *Species at Risk Act*; (iii) migratory birds as defined in subsection 2(1) of the *Migratory Birds Convention Act, 1994*; and (iv) any other component of the environment that is set out in Schedule 2; (*b*) a change that may be caused to the environment that would occur (i) on federal lands; (ii) in a province other than the one in which the act or thing is done or where the physical activity, the designated project or the project is being carried out; or (iii) outside Canada; and (*c*) with respect to aboriginal peoples, an effect occurring in Canada of any change that may be caused to the environment on (i) health and socio-economic conditions; (ii) physical and cultural heritage; (iii) the current use of lands and resources for traditional purposes; or (iv) any structure, site or thing that is of historical, archaeological, paleontological or architectural significance.

Environmental repercussions: Radical positive or negative change in the quality of life of humans (health and welfare) resulting from an alteration of the environment, including the quality of the ecosystem on which human survival depends.

Extraction: Action performed on a chemical compound to release its constituent elements by the use of a solvent (acid, base, etc.).

Federal authority: For the purposes of the CEAA (2012), (a) a Minister of the Crown in right of Canada; (b) an agency of the Government of Canada or a parent Crown corporation, as defined in subsection 83(1) of the *Financial Administration Act*, or any other body established by or under an Act of Parliament that is ultimately accountable through a Minister of the Crown in right of Canada to Parliament for the conduct of its affairs; (c) any department or departmental corporation that is set out in Schedule I or II to the *Financial Administration Act*; and (d) any other body that is set out in Schedule 1. It does not include the Executive Council of — or a minister, department, agency or body of the government of — Yukon, the Northwest Territories or Nunavut, a council of the band within the meaning of the *Indian Act*, Export Development Canada or the Canada Pension Plan Investment Board. It also does not include a Crown corporation that is a wholly owned subsidiary, as defined in subsection 83(1) of the *Financial Administration Act*, a harbour commission established under the *Harbour Commissions Act* or a not-for-profit corporation that enters into an agreement under subsection 80(5) of the *Canada Marine Act*, that is not set out in Schedule 1.

Follow-up program: For the purposes of the CEAA (2012), means a program for (a) verifying the accuracy of the environmental assessment of a designated project; and (b) determining the effectiveness of any mitigation measures.

Furans: Family of products with a composition and toxicity similar to those of dioxins.

Habitat: Areas or environment where a specific type of fauna or flora lives. The habitat provides the organism concerned with everything it needs to survive. Beaches, marshlands, rocky shores, bottom sediments, mudbanks and water are all typical coastal habitats.

Heavy metals: Term that refers to metals with a relatively heavy atomic weight, such as chromium, nickel, cadmium, lead, silver, gold, mercury, bismuth, copper, etc., and that can be precipitated by hydrosulphuric acid. In the soluble state, they are often toxic. Heavy metals can accumulate along the food chain.

Hydrocarbon (HxCy): Organic compound consisting of carbon and hydrogen. Petroleum is a natural mixture of hydrocarbons and other organic compounds.

Impact hypothesis: According to the Canadian Environmental Assessment Agency, series of statements linking the project's activities to their possible effects on the ecosystem elements.

Industrial effluents: Liquids released into the water or gaseous emissions. Solids or liquids not released into the water are called industrial waste/residues.

Inorganic: Generic term that refers to certain chemical components. In general, they cannot be incinerated and contain carbon only in non-combustible form. Not constituted of living matter.

Inorganic materials: Chemical substances of mineral origin.

Interested party: For the purposes of the CEAA (2012), means, with respect to a designated project, any person to whom it is determined that the person is directly affected by the carrying out of the designated project or the person has relevant information or appropriate expertise.

Interim measures: Management measures, such as limitation of access to the site or surveillance of its approaches, taken between the time a potential sediment contamination problem is identified and the time of remediation on the bottom of the waterway.

Invitation to tender: Procedure leading a certain number of enterprises capable of carrying out a project to prepare a proposal for a clearly defined set of tasks of a project.

Leachate: Water or any other liquid likely to contain dissolved (leached) soluble materials, such as organic salts and minerals coming from solids.

Leaching: a) entrainment by solubilisation of certain contaminants into a substance when it is put in contact with a liquid acting as a solvent (often water). In a discharge, wastes are mainly leached by rainwater; b) phenomenon of entrainment of the soluble elements of a waste by a solvent. On a landfill site, wastes are mainly leached by rainwater.

Lethal: Resulting in the death of the exposed organisms.

Maintenance dredging: Dredging intended to maintain the navigable depths in the navigation channels.

Management measures (options): Measures or actions considered necessary to limit or reduce the chemical or physical effects of dredging or disposal of dredged materials.

Mineralization: Decomposition of organic matter into mineral compounds.

Mitigation: The DFO Fisheries Protection Policy Statement (October 2013) defines mitigation as “measures to reduce the spatial scale, duration, or intensity of adverse effects to fish and fish habitat that cannot be completely avoided.”

Mitigation measures: For the purposes of the CEAA (2012), measures for the elimination, reduction or control of the adverse environmental effects of a designated project, including restitution for any damage to the environment caused by those effects through placement, restoration, compensation or any other means.

Mobility: Capacity of substances, under the influence of physical or chemical processes, to be released from their original medium or environment.

Offsetting: The DFO Fisheries Protection Policy Statement (October 2013) defines offsetting as : “measures to counterbalance *serious harm to fish* by maintaining or improving fisheries productivity after all feasible measures to avoid and mitigate impacts have been undertaken.”

Organic: Term that means carbon-based chemical components; in general, combustible. Regarding living creatures.

Organic matter: Chemical substances of animal or plant origin, or more correctly, with a carbon-based structure. This category includes most carbon compounds; most organic materials are combustible and a great many are volatile.

Organochloride: A synthesized organic chemical substance, derived from chlorine molecules and used for various purposes: insecticides, pesticides (e.g., DDT), fungicides, refrigerants, etc. Organochlorides are generally toxic and persistent.

Organochloride compound: Organic hydrocarbon in which one or more chloride atoms exist: typical compounds (HCB, HCH, dieldrin, DDT, PCB).

PCB: Generic name for polychlorinated biphenyls, organic compounds composed of phenolated compounds and chlorine atoms.

Permanent alteration to fish habitat: The DFO Fisheries Protection Policy Statement (October 2013) defines permanent alteration to fish habitat as: “an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.”

Physicochemical characterization: Analysis of sediments or interstitial water to determine its physicochemical properties or constituents (e.g., pH, particle size distribution, major ion concentrations, cation exchange capacity, redox potential, salinity, ammonia, total organic carbon, and total volatile sulphides).

Pollutant: A substance or a body that contaminates an environment. Physical, chemical or biological agent that harmfully alters the natural balance.

Pollution: Contamination of a natural environment by the direct or indirect human introduction of toxic products. Action of polluting, i.e. introducing an undesirable substance into an environment. Degradation of an environment after introduction of a pollutant.

Polycyclic aromatic hydrocarbons (PAH): Hydrocarbons in which the carbon atoms are arranged in two or more cycles.

Project: According to the CEAA, in relation to a physical work, any proposed construction, operation, modification, decommissioning, abandonment or other undertaking in relation to that physical work, or any proposed physical activity not relating to a physical work that is prescribed or is within a class of physical activities that is prescribed pursuant to regulations made under paragraph 59(*b*).

Proponent: For the purposes of the CEAA (2012), means the person, body, federal authority or government that proposes the carrying out of a designated project.

Quality assurance program: Duplication of all or part of the laboratory analyses to ensure that the desired precision and reproducibility levels are obtained.

Quality control program: Duplication of part of the chemical analyses (generally in an independent external laboratory) to estimate the overall quality of the outcomes obtained and determine, if necessary, what changes can be made to achieve or maintain the desired quality levels.

Registry: For the purposes of the CEAA (2012), means the Canadian Environmental Assessment Registry established under section 78 of the Act and consisting of an Internet site and project files.

Release of dredged materials: In this report, this term means any spill of dredged materials into a country's inland waters, regardless of whether these are deliberate disposal in open water, materials escaped from uncontained disposal sites (beach nourishment and other reuse), losses from a contained disposal site (effluents, surface runoff, percolation) or overflow from barges, hopper dredges or other transport vessels.

Remedial dredging: Dredging in navigable waters and in ports specifically intended to fight pollution.

Remediation: In relation to contaminated bottom sediments, elimination or mitigation of the effects of contamination by treatment, immobilization, extraction or other types of operation.

Responsible authority: For the purposes of the CEAA (2012), the responsible authority with respect to a designated project that is subject to an environmental assessment is (*a*) the Canadian Nuclear Safety Commission, in the case of a designated project that includes activities that are regulated under the *Nuclear Safety and Control Act* and that are linked to the Canadian Nuclear Safety Commission as specified in the regulations made under paragraph 84(*a*) or the order made under subsection 14(2); (*b*) the National Energy Board, in the case of a designated project that includes activities that are regulated under the *National Energy Board Act* or the *Canada Oil and Gas*

Operations Act and that are linked to the National Energy Board as specified in the regulations made under paragraph 84(*a*) or the order made under subsection 14(2); (*c*) the federal authority that performs regulatory functions, that may hold public hearings and that is prescribed by regulations made under paragraph 83(*b*), in the case of a designated project that includes activities that are linked to that federal authority as specified in the regulations made under paragraph 84(*a*) or the order made under subsection 14(2); or (*d*) the Agency, in the case of a designated project that includes activities that are linked to the Agency as specified in the regulations made under paragraph 84(*a*) or the order made under subsection 14(2).

Response plan: Program allowing quick and effective implementation of all the necessary means of response in case of emergency. Planning of the measures to be taken to deal with the unexpected in case of an accident. Within the context of an EMSP, all the control, mitigation, management or action measures considered necessary during the work to limit or reduce the physicochemical and biological impacts and the impacts on the human environment of dredging and sediment management activities. This response plan can also include the upward or downward revision of the EMSP. The emergency preparedness plans and the occupational health and safety programs are an integral part of a response plan.

Resuspension: New mixture of sediment particles and pollutants with water by storms, currents, organisms and human activities, such as dredging.

Risk: Measurement of the probability and severity of a harmful effect on health, physical property or the environment.

Screening: For the purposes of the CEAA, description of the designated project — other than one that is subject to a required environmental assessment — that includes the information prescribed by regulations to provide the Canadian Environmental Assessment Agency

Sediments: Layer of materials coming from any source, rock, or organic or volcanic material and transported by water from the original site to the disposal site. In watercourses, sediments are alluvial materials that move in suspension or by bed-load transport.

Serious harm to fish: The DFO Fisheries Protection Policy Statement (October 2013) defines serious harm to fish as: “the death of fish or any permanent alteration to, or destruction of, fish habitat. (Subsection 2(2)).”

Silt: Type of soil with cohesive properties, composed of grains with a diameter between 0.002 mm and 0.006 mm.

Solids: All materials, whether dissolved or not, volatile or not, present in sewers or water supply lines.

Spill: Any short-term accidental or deliberate release into the environment likely to cause a nuisance to the environment.

Study area: Unit formed by the study site and its vicinity (i.e., every sector likely to influence the study site), which requires surveillance or assessment.

Submersion: Action of disposal of substances at sea, in an estuary or in fresh water.

Suspended particulate matter (SPM): Matter that can be deposited or retained by filtering.

Sustainable development: Set of practices favouring development of resources that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. According to the CEAA (2012), development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Total organic carbon (TOC): Measures the quantity of carbon in a sample coming from organic materials only. This test is performed by combustion of the sample and analysis of the carbon dioxide produced.

Toxicity: Capacity of a substance to trigger alterations or disruptions in the functions of a living organism, leading to harmful effects, the most severe of which is the death of this organism. A substance's toxicity depends on the concentration and the duration of exposure. Two types of toxicity are distinguished: acute toxicity (short term) and chronic toxicity (long term).

Toxicity testing: Experiment with a view to determining the effect of a material or a substance on a population of a given species of organisms which have experienced specified conditions. Usually the proportion of organisms affected and the degree of the effect manifested after exposure to a given test substance are measured.

Toxic substance: Substance that may cause death, disease, behavioural anomalies, cancer, genetic mutations, physiological or reproductive anomalies or physical deformation in any organism or its offspring or that may become toxic after concentration in the trophic network or when combined with other substances.

Turbidity: Characteristic of water that is not transparent.

Valued ecosystem components: Any environmental component considered important by the proponent, the public, scientists and governments participating in the assessment process. Both cultural values and scientific concerns can serve as criteria to assess the importance of these components.

Volatility: Propensity to change into vapour. Chemicals with low vapour pressure are very volatile.

Volatile organic compound (VOC): Any carbon compound except carbon oxides, metallic carbides, carbonates and cyanides, likely to be found in the atmosphere at ambient pressure and temperature (e.g.. organic solvents, light hydrocarbons). The definition of a volatile organic compound often refers to specific sampling and analysis methods (e.g., U.S. Environmental Protection Agency).

Waste: Residues, materials, substances or debris released after a production or manufacturing process or use.

Source: Modified from Michaud (2000).

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Québec